AGRICULTURAL ENGINEERING

MAY • 1956

In this Issue . . .

Farm Equipment Design Development Accelerated by New Experimental Techniques

•

Lateral Pressures in Silage Provide Design Criteria for Horizontal Silos

•

New Method for Rapid Analysis of Stability Performance of Wheel-Type Tractors

•

Method of Forecasting Annual Soil Loss for All Combinations of Conditions

•

Engineer Points Way to Reduction in Farm Operating Time by Parallel Terraces

ASAE 49th Annual Meeting • Roanoke, Va., June 17-20

THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

3 NEW CASE COLOR FILMS ON FARM MECHANIZATION

Here in three new Case color films is the history of men and machines for the farm . . . the step by step progress from hand harvesting to automatic combining . . . the color and romance of the age of steam . . . and the behind-the-scenes story of the launching of the tractors of tomorrow.

You'll want these films for the education of your students, the entertainment of both young and old. See your Case dealer for prints . . . arrange now to show these films to all your students next fall. You are welcome to make use of these and other Case teaching aids—movies, booklets, slide films, posters, study outlines, reprints. J. I. Case Co., Racine, Wis.

"Centennial of Farm Mechanization"

Machines and methods from the past 100 years as shown at Michigan State University's "Centennial of Farm Mechanization" and "Land of Plenty" pageant at Lansing, August 15-19, 1955. Additional operational footage from the extensive Case film library.

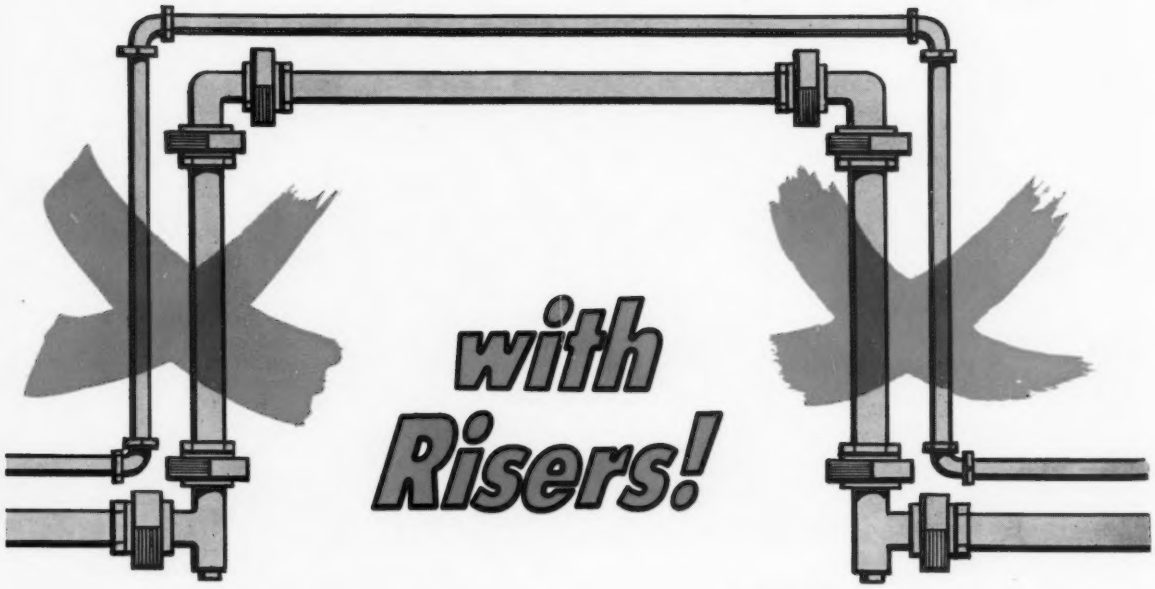
"When Steam Was King"

Look at the picture below and remember threshing time when you were a boy, eager to be part of the crew . . . let your audiences relive the days when steam was king . . . show your students the romance and excitement of the steam age. See steamers on parade!

"Operation Tractor Launching"

How a major manufacturer introduces a new tractor to his own organization . . . trains service men . . . and finally, presents it to dealers and farmers in field demonstrations is told in this newest of Case films, first of its kind in the industry.

NO TROUBLE



Surge has no trouble with risers because somebody around here was smart enough to write this set of words more than four years ago:

> "Finally: — Do NOT install a pipeline with a riser, as that almost certainly will lead to trouble . . . it always has . . . it seems to us that it always will. If there is just no possible way to install the line without a riser, then don't sell or install it."

They have had a prominent place in the Surge Instruction Book since that time.

If you have use for extra copies of this booklet please ask for them. Be sure to include your name and address.

Surge

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AGRICULTURAL ENGINEERING

Established 1920

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Yes, we have hayseeds in our hair

You don't ordinarily associate Clark Equipment with the business of farming, but we're in it—and in no small way.

On crop acreages, drainage, fertilizers, feeds and the like, we don't pose as authorities; but in the vital area of power equipment, without which modern farming wouldn't be modern, we know what we're talking about.

• A few years ago an implement manufacturer called us in. Said he, in effect—"We know power-farming, you know power transmission. Work with us to design what a tractor drive unit really ought to be."

• We jumped at that—who wouldn't?

Step 1 was to sweep out the rubbish of traditional thinking; and particularly the old idea that a conventional assembly of engine, transmission and axles on a frame constituted an industrial chassis.

Step 2 was to conceive, test and build an axle-transmission driving unit of truly functional design, stripped of every non-essential ounce of metal. That was done.

This intelligent collaboration seemed to us at the time, still appeals to us now, as the best way we know of to build a better machine: this pooling of a manufacturer's operations experience and Clark's half-century of engineering know-how in the basic field of power transmission.

Interesting sequels to that incident are two:

1. Other manufacturers of agricultural and industrial machinery, always alert for constructive ideas, called in Clark engineers — with equally gratifying results.

2. All those manufacturers are still thoroughly satisfied with their Clark Drive Units—and we are just as satisfied with the business of manufacturing them.

Is there a place at your planning table for Clark's engineering imagination and ingenuity and resourcefulness—for designing a new model or for modernizing a present one? They are yours to command. Let's explore the mutual advantages. A letter will make contact.

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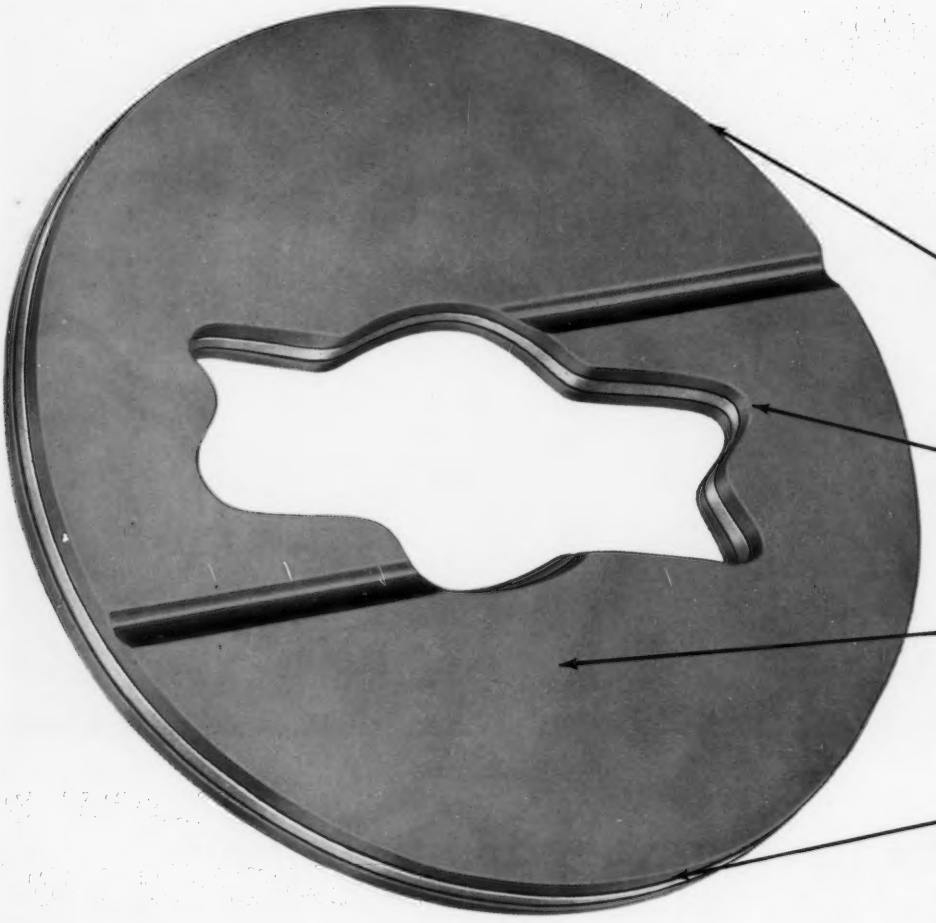
Automotive Division
Buchanan 1, Michigan


Solid bronze, or steel faced on one side with babbitt, or both sides with copper-lead.
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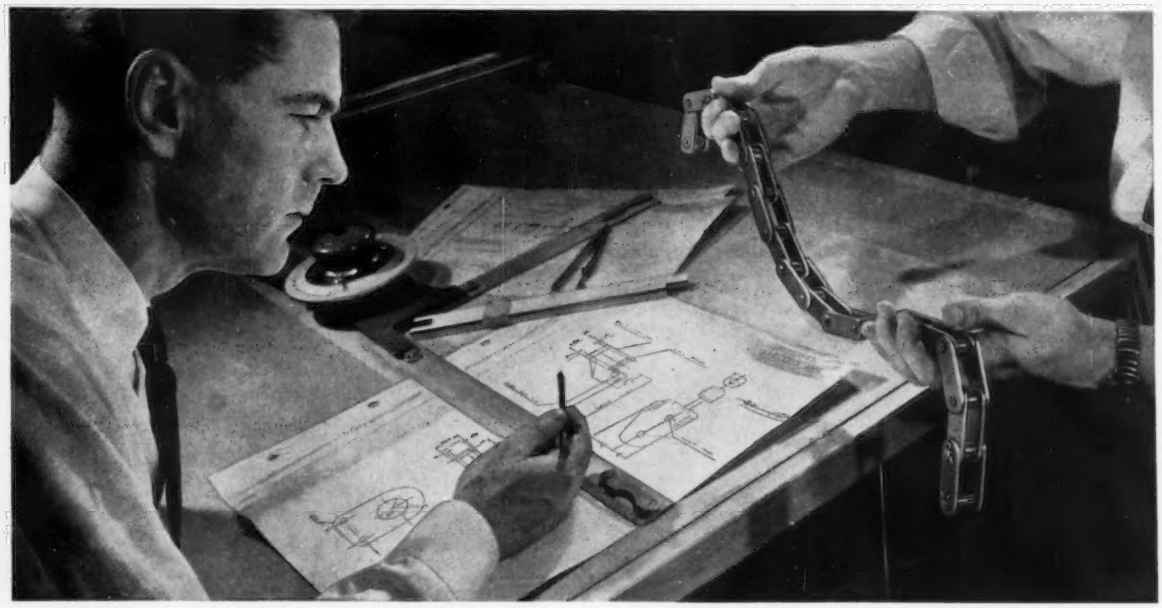
Need special attachments for chain?



LINK-BELT makes a broad selection and offers unmatched background in developing new designs

WHERE roller chain must be specially adapted for conveying, it pays to be as critical of attachment design as you are with the chain itself. That's why Link-Belt experience plus unmatched engineering and production facilities are so important to you.

For many applications, standard attachments proved on similar jobs are available. For special requirements, our engineers will work with you on the drawing board and in field-tests to see your need satisfied. Whether it's a simple sidebar hole or double-strand support to accommodate slats —long life and ample capacity are assured. In addition, the broad Link-Belt line of ASA single- and double-pitch roller chain and high-quality, low-cost "AG" roller chain provides the specialization you seek to meet all basic requirements.

For complete information on chain, attachments and matching sprockets, call the Link-Belt office in your area.

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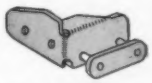
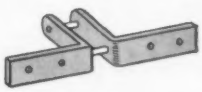
Typical LINK-BELT attachments developed for specific jobs

Used to convey corn on modern two-row picker.



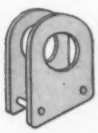
Holds slats for conveying grain or corn into combine cylinders.

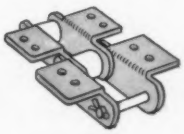
Used on gathering chains for corn pickers and forage harvesters.



Designed for single-strand elevators on corn pickers.

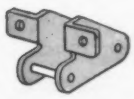
For interconnecting raker bars to convey hay on forage harvester.





Used with interconnecting slats on combine feeder.

For conveying and elevating, primarily on corn pickers.



Ford Equips New "250"

Dayton BSI* V-Belts Used For Rugged Plunger Drive

In 1954 Engineers at Ford Motor Company, Tractor and Implement Division, were in the final stages of development on a new baler—the "250"—especially designed for the farmer with small hay acreages. Equipped with a 15 hp motor and capable of baling up to 7 tph under average conditions, it was excellent for the farmer who needed a compact, maneuverable unit and didn't want to depend on a custom operator.

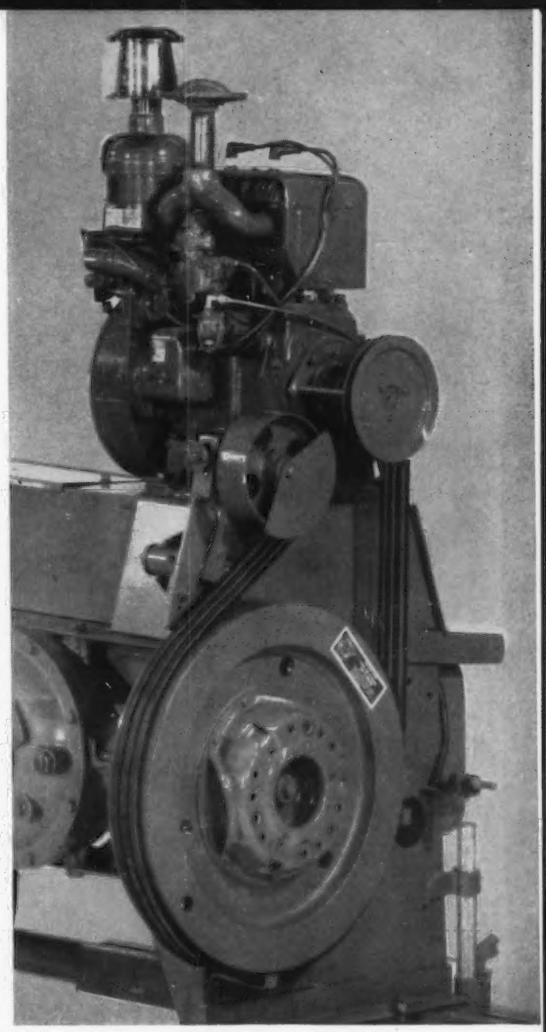
One innovation on the "250" is the use of V-Belts rather than flat belts for power transmission. Tests showed that heavy belt-stretching pulsation was set up by the baler plunger operating at 68 strokes per minute. In order to provide maximum uniform power and to forestall frequent replacement, Ford engineers decided to use V-Belts with minimum stretch characteristics.

Dayton V-Belt Engineers were among those consulted by Ford. They were asked to recommend a low stretch belt which would also take a terrific backbend.

Ford engineers had designed a spring idler to act as a clutch on the V-Belt so baling could be stopped without shutting off the engine. To accommodate the idler the V-Belts had to withstand a brutal backbend as well as possess superior forward flexibility to get maximum "wrap" around the comparatively small engine sheaves.

*Back Side Idler

Three Dayton HB section BSI V-Belts combine strength and two-way flexibility in this installation on Ford's "250" Baler. They transmit a maximum, uniform flow of power from the 15 hp air-cooled engine to the flywheel. Minimum stretch characteristics built into multiple-ply V-Belt helps a spring idler keep the three belts at proper tension at all times. The idler also acts as a clutch. A fly-wheel slip clutch, one of the outstanding Ford features, protects gears, connecting rod and plunger from damage due to overloading while baling.



Baler with V-Belts

DAYTON ENGINEERS RECOMMENDED the use of three Dayton Multiple-ply BSI V-Belts to develop the same power as the original flat belt and to beat the problem of pulsating load and two-way flexibility.

Dayton Back Side Idler V-Belts (shown below) are built specifically to withstand the stresses of reverse bending. Their special construction gives them the minimum stretch characteristics needed to resist pulsation.

FORD ENGINEERS accepted the multiple-ply BSI V-Belts after the severest of laboratory and field tests. They are now in use on "250" Balers all over the country.

In every case where you need V-Belts with minimum stretch characteristics, or for any V-Belt problem, contact your Dayton Agricultural Sales Engineer . . . or write Dayton Rubber Co., Agricultural O.E.M. Division, 1500 S. Western Ave., Chicago, Ill.

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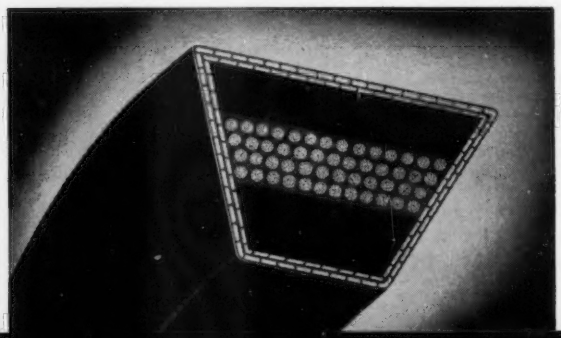

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First in Agricultural V-Belts

Agricultural Sales Engineers in Atlanta, Chicago, Cleveland, Dayton, Moline, New York, San Francisco and St. Louis

ONE OF A SERIES:

What makes a cylindrical roller bearing good?

RETAINERS

"requirement-engineered" for your kind of service

The basic parts of a roller bearing are the rollers, the races, and the *retainer* which locates and guides the rollers. There are significant differences in the design and construction of retainers, which influence bearing cost and performance. Some are simple and economical, well adapted for volume production; others are more costly but insure improved roller guidance, or cooler and smoother operation, or longer heavy-duty service. Here are the seven basic types in current use.

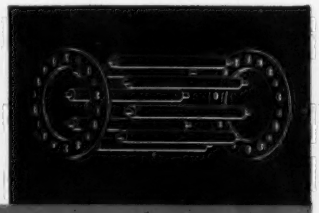
HYATT MAKES ALL SEVEN TYPES . . . EACH THE FINEST OF ITS KIND! **You will find complete details in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors, Harrison, New Jersey.**

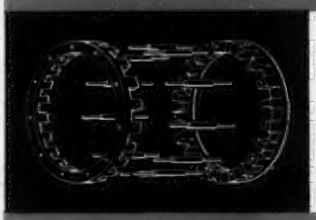
GM GENERAL MOTORS

HYATT

ROLLER BEARINGS

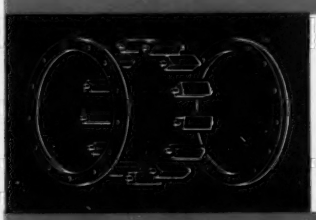
TRUNNIONED ROLLER CAGE—Economical for volume use on thin-annulus bearings. End rings are hardened steel stampings, connected by riveted bars interspersed between rollers to form an integral unit. Races can be omitted if desired.





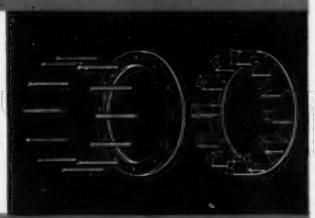
POCKETED END RING CAGE—Designed for fairly large bore bearings in heavy-duty service. Rollers are guided accurately by pockets drilled in bronze end rings. Riveted connecting bars form an integral unit, so races can be omitted if desired.

STAMPED STEEL SEPARATOR—Economical for volume use on wide range of bearings with short rollers. A single steel stamping with bars coined to conform to roller contour. Simple, open design assures large lubricant capacity and good circulation.



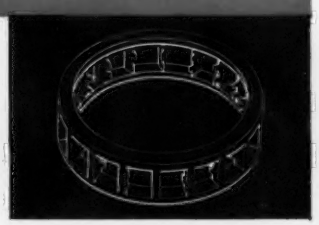
FORMED BAR CAGE—Well adapted for volume use on heavy-duty bearings. Hardened steel end rings are connected by cold-rolled shaped bars conforming to roller diameter. Insures quiet operation, better roller guidance, and the smooth surface of bars protects rollers.

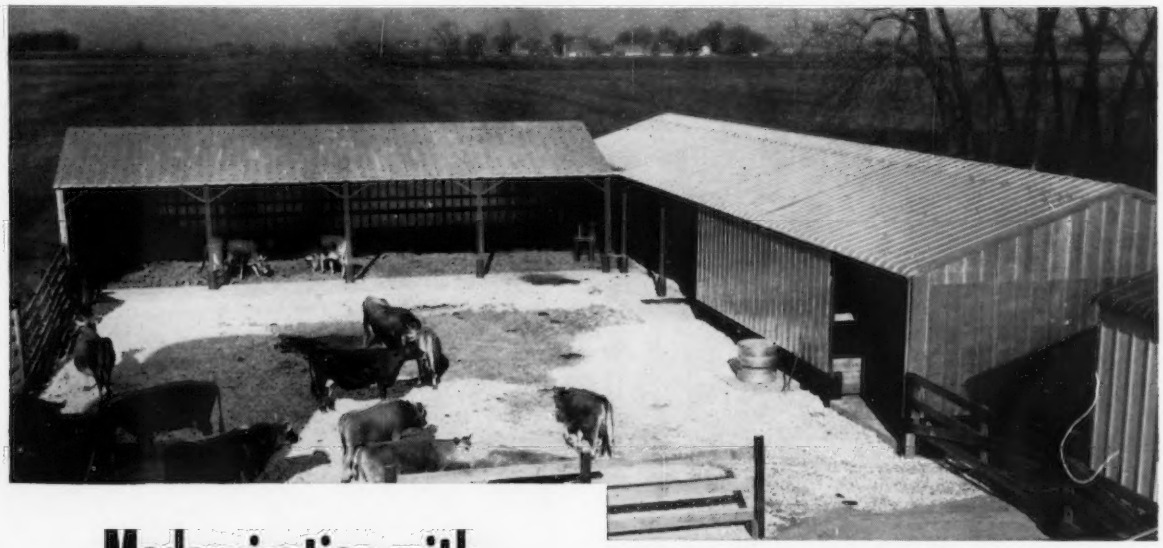
DRILLED POCKET CAGE—Used on better-grade bearings to provide extremely close control of rollers, which operate in pockets drilled and reamed in bronze cylinder. Riveted ring on one end retains rollers permanently, so races may be omitted if desired.



SEPARABLE BROACHED POCKET CAGE—Used only on finest high-speed bearings. An integral bronze cylinder with pockets broached for maximum uniformity. Insures minimum friction, better oil circulation for cooling. Rollers can be removed for inspection.

NON-SEPARABLE BROACHED POCKET CAGE—Similar to the above and offers all the same operating advantages. Used for "blind" installations where rollers must be retained with inner or outer race. Roller drop controlled by deforming bars after rollers are placed.





The above laborsaving arrangement of steel buildings illustrates the bedded loafing area on the left. The building on the right houses a hay and straw storage area with a self-feeding manger.

Modernization with Factory Built Steel Buildings

pays off handsomely for dairy farmer Ross Griffith of Galesburg, Ill.

Combination Milking Parlor—Milk House Building: contains a three-stall "U"-type milking parlor and a roomy, well-ventilated milk room. In addition to the above three buildings, the Griffith farm has a Factory-Built machinery storage building.

By installing Factory-Built Steel buildings for a loose housing system, Mr. Griffith has changed from a Grade C to a Grade A dairy operation—and now in less chore time than he formerly spent, he can handle twice as many of his registered Jerseys.

The use of versatile steel buildings, fabricated from USS Galvanized Steel Sheets with USS Structural Steel framework, makes this economic, time-saving operation possible. The clear span construction permits the use of mechanical equipment for manure and hay handling. Hay and silage are self-fed and concentrates are fed from hoppers in the insulated steel milking parlor.

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

WHEN YOU WISH TO MODERNIZE AND ACHIEVE THE SAME PAYOFF, THEN

SEND THIS COUPON FOR FURTHER INFORMATION

Agricultural Extension
United States Steel Corporation
Room 5306, 525 William Penn Place
Pittsburgh 30, Pa.

I am interested in steel buildings for the following:

☐ *dairy barns* ☐ *hay storage* ☐ *machinery storage*
☐ *cattle shelters* ☐ *grain storage* ☐ *poultry houses*

☐ *other* .....

Approximate size or capacity .....

Send information to:

Name .....

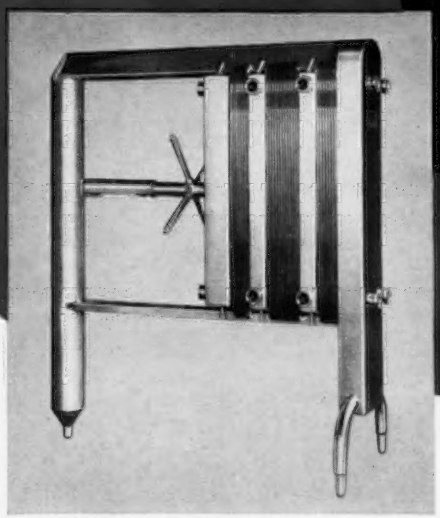
Address ..... **Town**.....

County ..... **State**.....

United States Steel Corporation produces high-quality USS Galvanized Steel Sheets and Structural Steel which our customers manufacture into durable farm buildings. Your request for information will be forwarded to the manufacturers of these buildings, and you will hear directly from them.

UNITED STATES STEEL

Critical purity depends on precision processing



C/R MOLDS, BONDS GERM-PROOF PLATE SEAL

First concern of the Kusel Dairy Equipment Company was to provide for exceptional sanitation in the commercial plate heat exchangers they manufacture. Because bacteria can multiply rapidly in the smallest crevice or pocket, each pressure gasket had to be bonded so precisely that no loose edges or imperfections could exist between the gasket and the stainless steel plate to which it is bonded. Also, the gasket had to be tasteless, odorless, able to withstand high temperatures and cleansing solvents; it must resist the action of fatty acids, and possess lasting elasticity for consistent sealing performance. Kusel worked with C/R Sirvene engineers . . . and got the answer. C/R's specially compounded Sirvene (synthetic rubber) material meets every specification . . . including the critical tolerances and bonding precision required to permit the high degree of cleanliness and purity demanded of the dairy industry.

If you have a sealing problem—critical or simple—C/R Sirvene engineers can help you. They're established leaders in the compounding and molding of elastomers for fluid sealing and related applications . . . and backed by the finest research and production facilities to solve your problem quickly, economically. Write them direct, or write for the new booklet, "Sirvene."

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CHICAGO RAWHIDE

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158 Reasons

why *Fast-Hitch* means sales opportunity unlimited...for IH Dealers

126 TYPES AND SIZES OF McCORMICK® FAST-HITCH IMPLEMENTS

32 ITEMS OF SPECIAL DUTY EQUIPMENT

158 TYPES AND SIZES OF FAST-HITCH equipment add up to an important sales plus for the IH franchise . . . Only IH Dealers can offer prospects the time-saving and performance-improving benefits provided by Fast-Hitch, over such a wide range of tractor sizes, for so many different jobs!

INTERNATIONAL HARVESTER

International Harvester products pay for themselves in use—McCormick Farm Equipment and Farmall Tractors . . . Motor Trucks . . . Crawler and Utility Tractors and Power Units—General Office, Chicago 1, Illinois.

Two Important Phases of
UPSTREAM WATERSHED DEVELOPMENT

Farm power contractor, William Kubik, Wahoo, Nebraska, is doing much to help farmers control runoff throughout the small watershed areas of northern and central Nebraska. His wide experience with conservation practice . . . his thorough knowledge of soils and water control measures . . . backed by the proper Caterpillar equipment for every job, assures his customers of dams, ponds, terraces and ditches built to specifications at lowest cost.

POND BUILDING . . .

Contractor Kubik's CAT D6 Tractor and No. 60 Scraper are shown loading stiff, yellow clay in this pond bed. In the background, another D6 and 'dozer build the spillway. The dam is 380 'long by 18' high with an 8' crown. The total job involves moving 3600 cu. yd. of dirt from an area covering several acres. Mr. Kubik says, "Cat-built machines are easy to operate, repair bills are low, and resale values are high."*

TERRACE CONSTRUCTION . . .

Mr. Kubik's Caterpillar No. 12 Motor Grader is shown building terraces and waterways to lead the water slowly downhill to pond or drainage ditch. He has standardized on Caterpillar equipment and realizes many benefits: D6 Tractors and No. 12 Motor Grader all have the same basic engines — which simplifies his machine care and operator training. Long-lasting performance and economy of Cat machines help him profit.

Your Caterpillar Dealer is a good man to see when you're planning a soil conservation program. He can put you in touch with efficient farm power contractors in your community and recommend the equipment that can do your jobs best. You can have confidence in the equipment he sells, because Cat machines have cleared more land, moved more dirt than any other man-made power on earth!

CATERPILLAR TRACTOR CO., Peoria, Illinois, U.S.A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

DIESEL TRACTORS • MOTOR GRADERS
ENGINES • TOOL BARS AND TOOLS
EARTHMOVING EQUIPMENT

BCA

Standard . . . or custom-made

BCA BALL BEARING PACKAGE UNITS

improve implement performance . . . reduce manufacturing costs

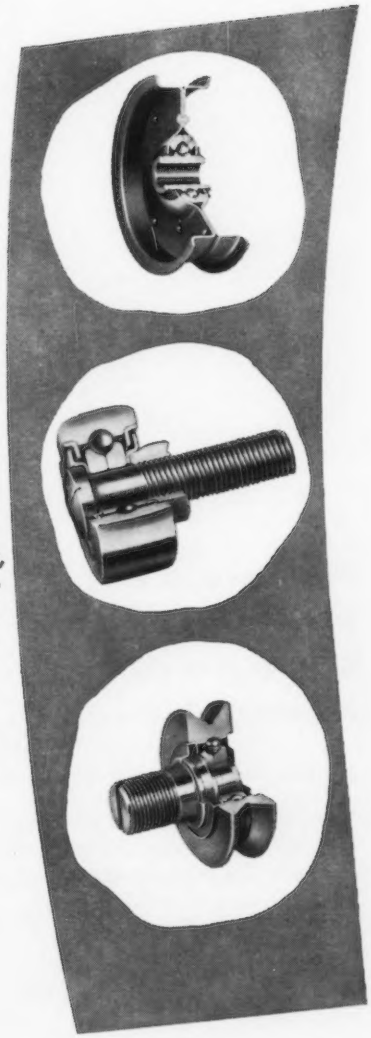
There are two ways in which you can benefit from BCA's long experience in the design and production of pre-lubricated ball bearing package units for farm implement applications.

- Use standard BCA package units on your assembly line.
- Count on BCA for skilled assistance in designing custom-made package units for special applications . . . or for use in new implements you plan to manufacture.

Choose one or the other . . . or both. You will find that you can reduce assembly time and costs . . . improve product performance, too.

BCA packaged units combine the bearing, its housing, and an effective seal in a single rugged unit capable of handling the loads, speeds and operating conditions encountered in farm work. Lubricated for life, standard packaged units are available for many applications including idler pulley assemblies . . . cam followers . . . plunger rollers . . . hay rake bearings . . . grains drills . . . others.

BCA pioneered the development of pre-lubricated package units for agricultural use . . . can help you find the right answers to any ball bearings problem you may have.



BCA

BEARINGS COMPANY OF AMERICA

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

LANCASTER • PENNSYLVANIA

Pioneers of pre-lubricated *package unit* ball bearings for agriculture

Products of French & Hecht Division of Kelsey-Hayes

for the workhorses of modern agriculture

From the monsters of the fields to the highway vehicles that whisk the final product off to market —wheels are vital to the speed and efficiency of modern mechanized farming.

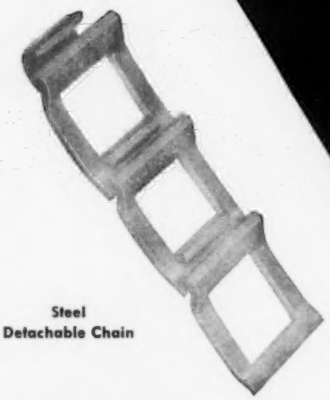
Making wheels for agriculture is a Kelsey-Hayes specialty that started 67 years ago at the French & Hecht Farm Implement and Wheel Division in Davenport, Iowa.

KELSEY-HAYES

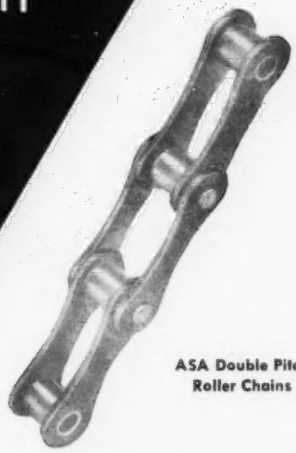
Kelsey-Hayes Wheel Co., Detroit 32, Mich. • Major Supplier to the Automotive, Aviation and Agricultural Industries

TEN PLANTS / Detroit and Jackson, Michigan; McKeesport, Pa.; Los Angeles, Calif.; Windsor, Ontario, Canada • Davenport, Iowa (French & Hecht Farm Implement and Wheel Division) • Springfield, Ohio (SPECO Aviation, Electronics and Machine Tool Division)

fills the gap in implement chains

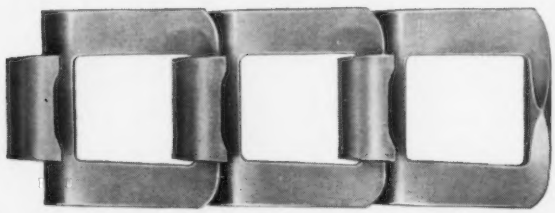


Steel
Detachable Chain



ASA Double Pitch
Roller Chains

A NEW, STRONGER, LONGER LASTING STEEL DETACHABLE CHAIN..."HF" BY CHAIN BELT



For implement applications that require a steel detachable chain that is stronger . . . lasts longer than standard steel detachable . . . New Rex "HF" (High Fatigue Strength) Chain is the ideal answer. At only slightly higher cost, this new chain provides many outstanding advantages:

- **Much higher fatigue strength**
- **Greater tensile strength**
- **Better bearing area assuring less wear and elongation**
- **Easy detachability and coupling . . . eliminates accidental uncoupling in service**
- **Long-life projection-welded attachments**

Investigate the many advantages NEW Rex® "HF" Steel Detachable offers you. Check, too, on the other new developments in implement chains, "AR" and "A" Series Chains, developed by the leader in implement chain design—CHAIN Belt. Your CHAIN Belt District Sales Engineer will be happy to give you the complete details. Write CHAIN Belt Company, 4680 W. Greenfield Ave., Milwaukee 1, Wisconsin.

CHAIN BELT COMPANY

Milwaukee 1, Wisconsin

All off-the-highway earth-moving equipment... dozers, scrapers, dump trucks... pose special hydraulics problems. The bulk, tonnage, and rugged service impose conditions that shoot an "ordinary" or "standard" formula full of holes. This is true of all heavy-duty equipment and especially so with long-stroke telescopic cylinders!

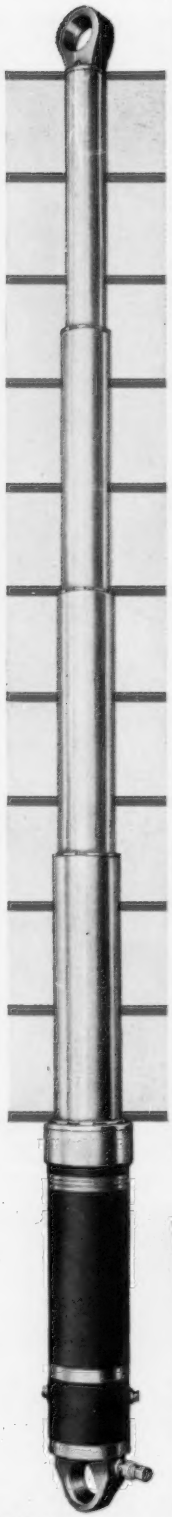
HYDRECO®

LONG-STROKE HYDRAULIC TELESCOPIC CYLINDERS

HYDRECO Cylinders are the result of many years of design and production experience. They're custom built for the service they face. They can be designed to meet your special requirements of space, mounting, function and load. You can have HYDRECO Cylinders with strokes to 20 feet or more and for loads requiring outer sleeves as large as 10 inches in diameter and system pressures to 1500 psi.

Telescopic cylinders are tough to build. No other cylinder calls for such close tolerances and perfect finish... no other type requires so much in design and production "know-how." Engineers who want "the bugs" out of their heavy-duty mobile equipment from the start specify HYDRECO!

Whether your problem involves 1 ton or 75 tons, the broad experience of HYDRECO engineers in finding the *right* answer can save you time, money and grief.



Write

—let HYDRECO engineers show you how you can improve your equipment with custom-built HYDRECO Telescopic Cylinders.

Member NFPA

KALAMAZOO DIVISION
THE NEW YORK AIR BRAKE COMPANY

9007 E. MICHIGAN • KALAMAZOO • MICH.
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

BIG DART EQUIPMENT SPEEDS CONSTRUCTION

OFF-THE-ROAD DUMP TRUCKS CARRY 75 YARDS PER LOAD

It's no problem at all to carry away, in a single load, half the dirt from an average home basement excavation. Modern off-the-highway dump trucks, hauling 75 tons or more of earth and over-burden, make short work of moving a hill or filling a valley.

Dumping these giant loads is done by means of big Telescopic Hydraulic Cylinders. Because truck bodies are so large, they require cylinders of unusually long stroke and capacity to raise them to full dumping position. During this operation it's an absolute "must" that all sleeves extend smoothly with no sticking or binding. Above all, safe operation is essential.

Downtime with this equipment costs big money. These giant trucks run day and night, rain or shine, on all sorts of jobs — so, cylinder maintenance must be negligible.

Many truck builders have made these big models practical and profitable with HYDRECO Fluid Power. Their experience has shown that HYDRECO Cylinders do the job and that they're safe, smooth operating and require a minimum of maintenance.

One of these builders is the Dart Truck Company, Kansas City, Mo., whose new 75-Ton capacity dump body is shown here. This model uses two 120-inch stroke HYDRECO Telescopic Cylinders. Fluid Power for the circuit is provided by two HYDRECO Pumps and control is by means of a HYDRECO Hollow-Plunger Valve.

ENGINEERS
Exceptional opportunities for men of imagination to express new ideas in the design and development of Fluid Power components. Company expansion and progress promise rewarding futures for engineers who qualify. Write, giving experience and full details.

KALAMAZOO Division
The New York Air Brake Company
9007-5 E. Michigan, Kalamazoo, Mich.

Gentlemen: We'd like to discuss the subject of Telescopic Cylinders with one of your engineers. We understand there is no cost or obligation for this cooperation.

Name_____

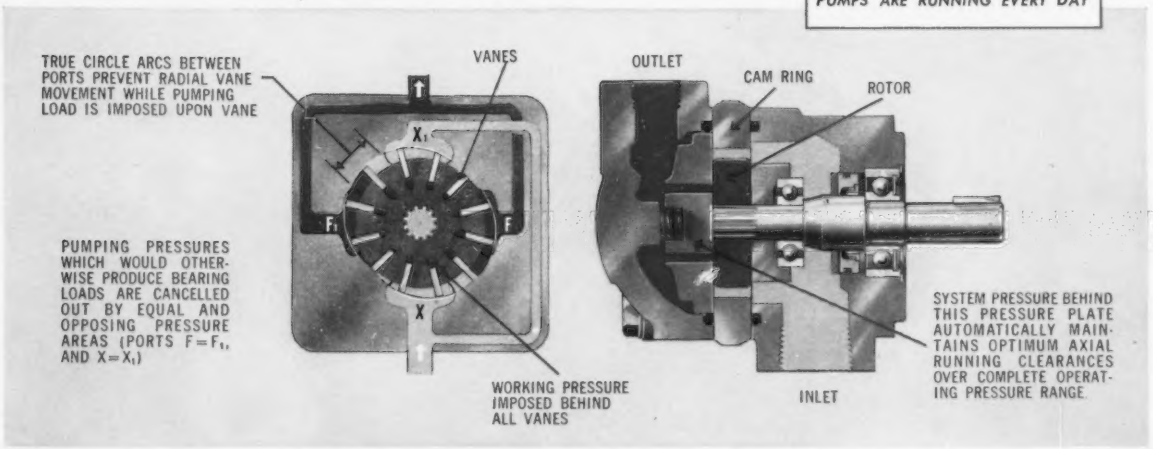
Company_____

Address_____

City_____ Zone____ State_____

Question: Why are VICKERS® Balanced Vane Pumps the most widely used oil hydraulic power pumps on mobile equipment?

MILLIONS OF VICKERS VANE TYPE PUMPS ARE RUNNING EVERY DAY


TRUE CIRCLE ARCS BETWEEN PORTS PREVENT RADIAL VANE MOVEMENT WHILE PUMPING LOAD IS IMPOSED UPON VANE
VANES
OUTLET
CAM RING
ROTOR
PUMPING PRESSURES WHICH WOULD OTHERWISE PRODUCE BEARING LOADS ARE CANCELLED OUT BY EQUAL AND OPPOSING PRESSURE AREAS (PORTS F=F1, AND X=X1)
SYSTEM PRESSURE BEHIND THIS PRESSURE PLATE AUTOMATICALLY MAINTAINS OPTIMUM AXIAL RUNNING CLEARANCES OVER COMPLETE OPERATING PRESSURE RANGE
WORKING PRESSURE IMPOSED BEHIND ALL VANES
INLET

Answer: Because of their SUPERIOR PERFORMANCE and MANY OTHER BENEFITS for the user.

For more than two decades, the Vickers Balanced Vane Type has held the leading position among hydraulic power pumps . . . growing steadily in popularity. The various models (only a few shown below) are *the most widely used of all pumps in oil hydraulic service on mobile equipment.*

The many advantages listed hereafter merit the thoughtful attention of anyone concerned with the selection and use of oil hydraulic pumps for construction, automotive, agricultural and materials handling equipment.

COMPLETE HYDRAULIC BALANCE—Each inlet and outlet port is balanced by another equal in size and radially opposite . . . pressure-induced bearing loads are thus eliminated.

OPTIMUM RUNNING CLEARANCES—Both radial and axial clearances are automatically maintained over complete operating pressure range and throughout pump life.

FLOATING ROTOR DRIVE—Rotor is free to float, for correct centering and alignment, on a rigidly supported spline.

TRUE-CIRCLE CAM ARCS between ports prevent radial vane movement while pumping load is imposed upon vanes. Wear between vanes and rotor is thus practically eliminated.

EASIER COLD WEATHER STARTING—At normal engine starting speeds vanes are retracted . . . centrifugal force is insufficient to throw vanes outward into operating position . . . thus no pumping action takes place and pump drag on starting engine or motor is nonexistant. Only after engine starts is speed sufficient to extend vanes and begin pumping.

GREATER INSTALLATION ADAPTABILITY—Various types of mountings and four optional positions of pressure outlet connection. By unbolting and rotating pump head, the outlet can be placed parallel, opposite to or at a right angle in either direction to inlet. Shaft drive is in either direction depending only on internal assembly. Pump can be driven by belt, chain, gear or directly coupled.

HIGHER EFFICIENCY—Tests prove exceptionally high volumetric and overall efficiency . . . not only when pump is new but also after long service.

AUTOMATIC WEAR COMPENSATION—Vanes are held in contact with the cam ring by centrifugal force and hydraulic pressure. If wear occurs, vanes revolve in a slightly larger orbit without appreciable change in performance.

TEMPERATURE ADAPTABILITY—Correct running clearances are automatically maintained which compensate for wide variation in oil viscosity resulting from temperature variation.

MINIMUM MAINTENANCE—Hydraulic balance . . . optimum running clearances . . . floating rotor drive . . . automatic wear compensation eliminate the most important causes for maintenance and repair.

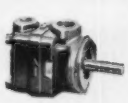
LONGER LIFE—The numerous features mentioned above that keep down maintenance also contribute to longer life.

COMPACT—These pumps occupy very little space in proportion to their capacities.

CONSTRUCTION SIMPLICITY is evident from the illustrations above. This simplicity is another reason for the superiority of Vickers Vane Pumps. For further information, ask for Bulletin M-5101.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1516 • Detroit 32, Michigan
Application Engineering Offices: ATLANTA • CHICAGO CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) SEATTLE • ST. LOUIS • TULSA • WASHINGTON WORCESTER
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

Single pump available in five basic case sizes having 15 normal delivery ratings. Operating pressures to 1500 psi (two largest units to 1000 psi).



Double pump for operating two independent hydraulic circuits from one power source. Available in 38 combinations. Operating pressures to 1500 psi (two largest units to 1000 psi).

"Package" type pump with integral volume control and relief valve, and oil reservoir; also available without oil reservoir. See Bulletin M-5107. (This pump only.)

ALL MODELS HAVE THE VICKERS ADVANTAGES MENTIONED ABOVE

7353

IN 9 CASES OUT OF 10
the Gauges Are Made By Rochester

And odds are they will give him accurate indications of generator current, temperature, fuel level and oil pressure for the life of his tractor. Such is the record of RMC engine gauges . . . *9 out of 10* major tractor manufacturers use one or more of these dependable instruments consistently.

These same RMC gauges are also used extensively on stationary engines, along with the RMC pressure switch, in irrigation and water supply systems. Built to withstand shock and vibration, and hermetically sealed against dust and moisture, these instruments will always be found where performance requirements are high and the going is rough.

Look to RMC for Full-Line Instrumentation

PRESSURE GAUGES
Illustrated here is a heavy-duty water pump gauge. Sealed from dust, and moisture proof. What are your pressure gauge problems?

FUEL GAUGES
Illustrated here is a tank-mounted fuel gauge with magnetically driven pointer. Head pressure tight to tank contents. Sealed against dust and moisture. What are your fuel gauge requirements?

Manufacturers: TELL US YOUR REQUIREMENTS FOR DIRECT MOUNTING AND REMOTE INDICATING INSTRUMENTS, AND LET RMC ENGINEERING SKILL PROVIDE THE ANSWERS!

Sold Only As Manufacturer's Original Equipment.

RMC

"You Can Rely On Rochester"

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC.
99 ROCKWOOD STREET • ROCHESTER 10, N.Y.

Morse Roller Chain provides vital drives in 12-ton-per-hour New Holland Hay Baler

Detail of New Holland Super 77 Hay Baler, showing Morse Double-Pitch Roller Chain on knotter drive. This is one of four vital baler drives utilizing Morse Chain.

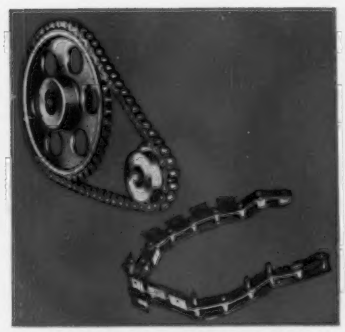
"One of the four places in our new Super 77 Hay Baler where we use Morse Chain is in the vital drive of the knotter assembly," reports New Holland Machine Company (New Holland, Penn.), leading agricultural equipment manufacturers. "This one important chain controls the plunger action while the bale is being tied.

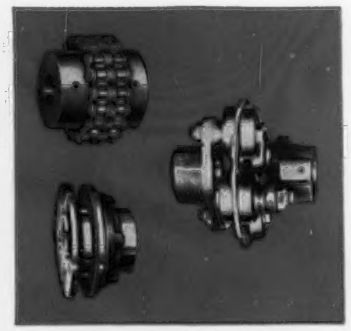
"From long experience in manufacturing grassland equipment, New Holland knows how important the action of this one chain is in the knotter assembly. The chain's reliability can make or break a farmer's baling record for the day or for the season."

Leading farm machine makers across the country depend on Morse for power transmission equipment. Morse makes a complete line of roller chain, couplings, sprockets, torque limiters, and special-purpose roller chain attachments for conveyors, etc.

Free help and information

Write, wire, or call today for information on any phase of your product development which involves power transmission. Or call in our local expert, your nearby Morse Distributor.





MORSE PRODUCTS FOR AGRICULTURAL EQUIPMENT

Morse Roller Chain Drive. Special double-pitch chain mockup, showing variety of special attachments.

Morse Roller Chain Couplings, Morflex Flexible Couplings, adjustable Morse Torque Limiter.

MORSE CHAIN COMPANY
INDUSTRIAL SALES DIVISION
ITHACA, N.Y.

MORSE MORSE B-W *trademark **POWER TRANSMISSION PRODUCTS**

FAFNIR BUILDS PLANT NO. 6

New five-acre plant at Newington, Connecticut will streamline machining and heat treating operations

Fafnir Plant No. 6, now nearing completion, will house the most modern machining and heat treating equipment and will provide for economical storage and handling of steel.

The opening of this large plant represents an increase in floor area of about 20% and an important step in a long-range program to speed production of over 10,000 types and sizes of Fafnir ball bearings and ball bearing units. The plant occupies one corner of a hundred-acre site which will make possible a four-fold expansion.

Fafnir's 18 strategically-located branch warehouses and its coast-to-coast network of authorized distributors will soon reflect the added productive capacity which these new facilities make possible.

The Fafnir Bearing Company,
New Britain, Connecticut.

Any type, any size, for any purpose . . . all made to the highest standards of quality.

FAFNIR

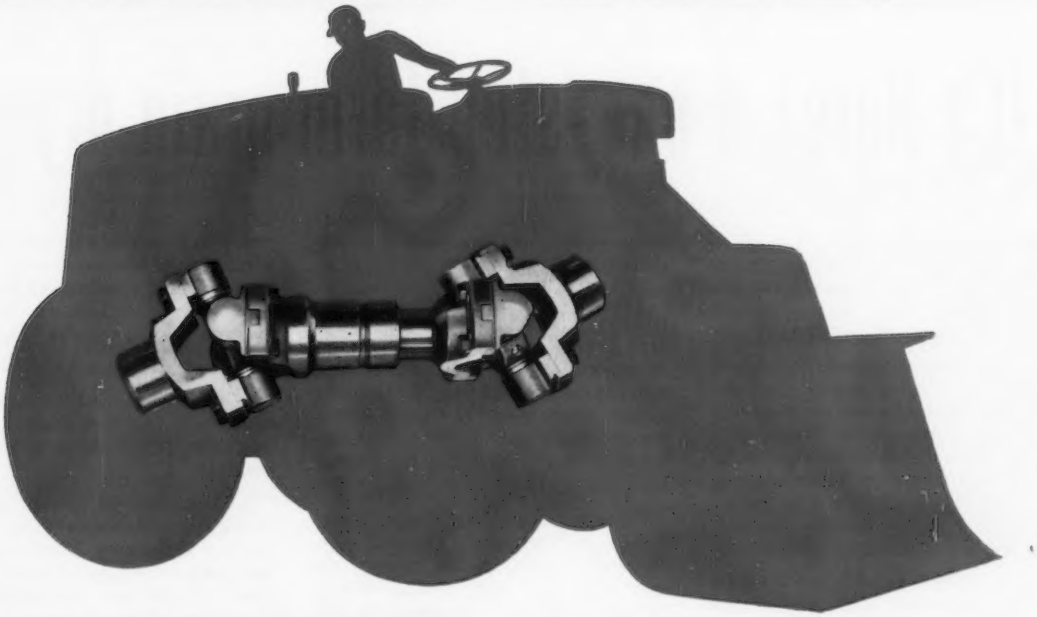
BALL BEARINGS

Most Complete Line in America

VERSATILE

MECHANICS Roller Bearing UNIVERSAL JOINTS excell for both main drives and controls — in all kinds of material handling trucks. Have transmission flanges for any type of brake drum. Easy to service —

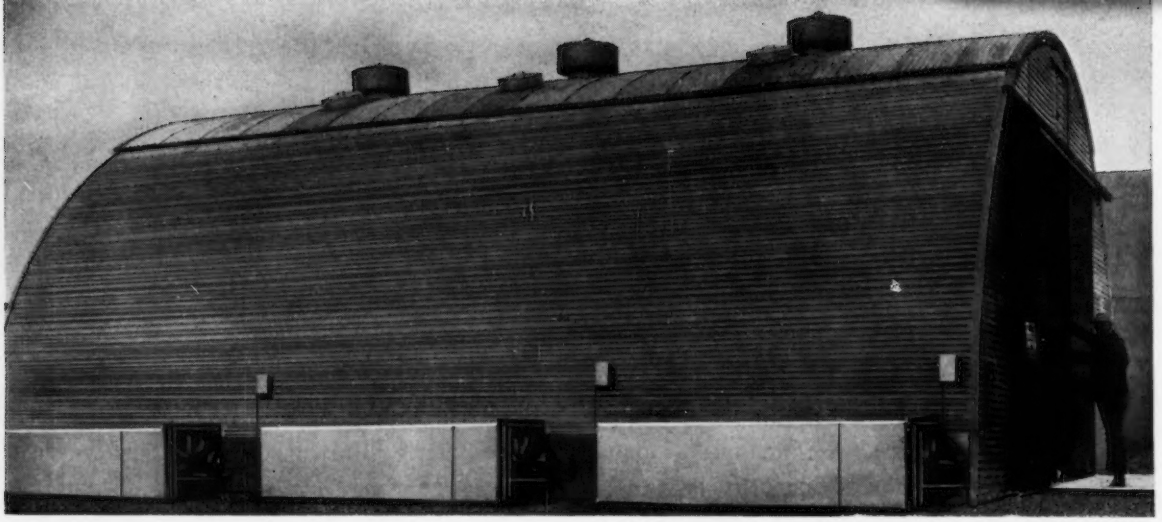
MECHANICS Close-Coupled UNIVERSAL JOINTS transmit more power — in less space — at greater angles than any other joints. Let MECHANICS engineers help give *your* machines competitive advantages.



MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2046 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International
79 E. Adams, Chicago 3, Illinois

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment



It's Here! A one-stop farm grain dryer!

A REVOLUTIONARY new method of on-the-farm drying of small grains and shelled corn with unheated air has been developed by Stran-Steel Corporation.

It incorporates a specially designed multiple-fan drying system that fits any of the three Quonset grain storage buildings, regardless of length. The drying system is extremely flexible. As a building's length is increased, new fans and drying tunnels may be installed in the new addition without affecting the original fan installation.

Using 24-inch fans driven by 5-hp motors (maximum size), the drying system is specifically designed for rural lines in areas where only single-phase current is available.

Another important feature of this natural air drying unit is the built-in cooling system. The same fans that do the drying are reversed to cool the grain in storage. There are no extras to buy.

The design of this new drying system is based on research done at eight state agricultural experiment stations throughout the country with rice, shelled corn, oats and grain sorghum. Research was conducted under many different weather conditions and in the extreme humidity of the Gulf Coast area. The system was carefully tested for air delivery both in the laboratory and under actual farm conditions with various crops in principle grain growing areas of the country.

Thus any farmer, no matter where he lives, can buy the Quonset drying system with confidence.

The Quonset grain drying package is especially adapted for in-storage drying and cooling of shelled corn. After corn is field-shelled and elevated into the storage building, the Quonset system takes over. The grain is not handled from the time it is first elevated into the building for drying until it is sold or fed.

As recently as 1954, Ernest Ham, Saronville, Nebraska, harvested corn like anyone else. Double crews—five men and two corn pickers—began harvesting 500 acres of corn in the fall and sometimes didn't finish the job until spring. Ham then had to crib the corn over winter, spring and summer and pay 2¢ a bushel to have it shelled before A.S.C. called for delivery.

If, during the storage period, the corn took on moisture, Ham had to laboriously move it or the spoilage was his loss.

Last fall, however, things were different. There were no corn picking crews other than farmer Ham and a coworker. In little more than three months, these two men field-shelled 7500 bushels of corn with a combine, rapidly dried it with unheated air to 13½ percent moisture, and, in the same building, stored it under loan.

Ham's drying system reduced moisture content to A.S.C. specifications for less than one-half the cost of heated-air drying. His electricity bill was $75. That's 1¢ a bushel for drying, compared to between 3 and 4 cents a bushel that it costs to dry corn using heated air.

Here's how Ernest Ham harvested and dried his corn crop:

1. He field-shelled his corn with a combine in October, weeks before his neighbors put their corn pickers in the field.

2. Averaging 20 percent moisture, 7500 bushels of corn were elevated into the 32 x 36 Quonset. The three 24-inch fans were started, forcing air into three manifolds and nine drying tunnels.

3. In a few short weeks moisture content in the corn was reduced to 13½ percent and cooled for safe storage.

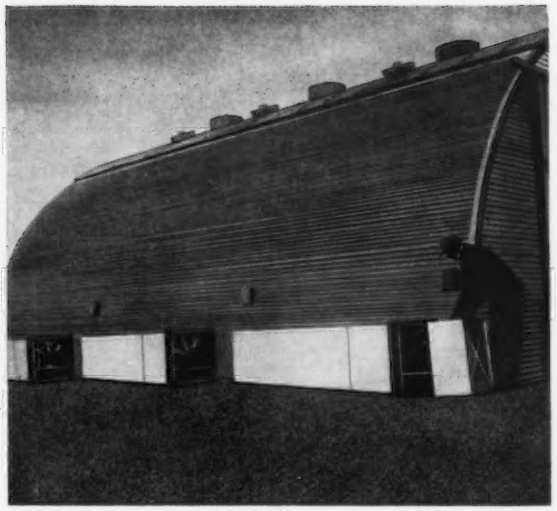
4. The corn was stored under A.S.C. loan in the same building in which it was dried. Both drying and cooling were done with the same fans and without moving the corn.

This Nebraska farmer's grain drying system met U.S.D.A. recommendations by delivering 3 cubic feet of air per minute per bushel for drying shelled corn at 20 percent moisture at the 10-foot level.

Corn—as well as small grain—may be piled from 6 to 12 feet deep for drying, depending on moisture content and rate of filling.

"The big thing that sold me on the new Quonset drying system was labor," Ham indicated. "I once trucked corn 12 miles to be dried. Now it's

These three 24-inch high-capacity fans dry with unheated air and are easily reversed to cool grain in storage.



When inoperative, fans and motors are weather protected by metal covers on Ernest Ham's Saronville, Nebraska, farm.

done right on my farm. Shelled corn is brought in from the field and elevated into the Quonset for drying. Whenever the corn heats or takes on moisture, I turn on the fans. It's that easy. The corn combine and picker-sheller are coming into their own around here and the new Quonset dryer is just the system we've needed to go with them. It takes only a few weeks for two men to pick, shell, dry and store my corn now. In 1954, it took months."

Ham jumped on the corn-drying bandwagon fast. He contracted with Quonset dealer John W. Wilkins of Geneva, Nebraska, for a building on October 22, 1955. Erection began on October 24. Eight days later the drying system had been installed and Ham elevated the first truckload of shelled corn into the Quonset.

"News like this travels fast," Ham said, gesturing toward his new Quonset building and drying system.

"Quonsets are pretty well known as *the* grain storage building in this area. They can't be beat. Now that I've seen the results, I'd say the same thing about the new grain drying system."

There's a Quonset for Every Job on your Farmstead

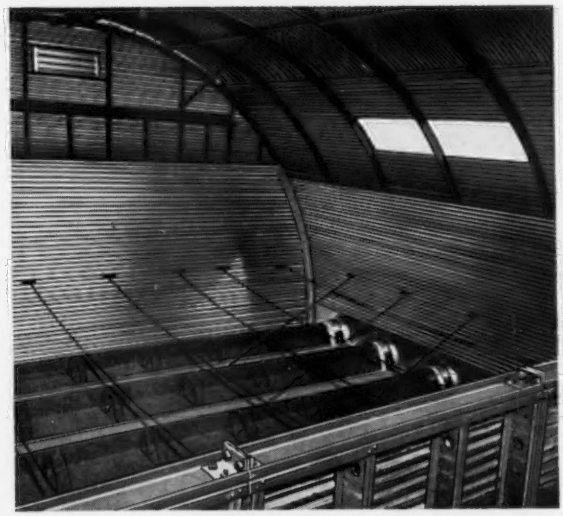
Stran Steel

STRAN-STEEL CORPORATION

Ecorse, Detroit 29, Mich. • A Unit of

NATIONAL STEEL CORPORATION

56-SS-26A



Interior view of Quonset building shows tunnel system and method of reinforcing walls to withstand grain pressure.

New grain drying system reduced moisture content of Ham's shelled corn from 20 to 13½ percent, safe for A.S.C. storage.

Tough Tillage?

Below: Athens Model F 16/22 Harrow discing cornstalk land with Ingersoll Dura-Notch discs.

easy does it... with Ingersoll Discs

Handling tough tillage jobs is all in the day's work for this Athens No. 23 disc plow equipped with husky 26-inch Ingersoll discs. Plowing soils that are hard and dry, sticky and heavy, overgrown with tough sod, or infested with roots, stumps or stones—this Athens-Ingersoll team turns the earth with ease.

Whatever the soil condition, Ingersoll discs work better—longer. That's because they're (1) the only discs made of TEM-CROSS® steel, the steel that's *cross*-rolled for top resistance to splitting and curling under impact; (2) specially heat treated and tempered to assure proper hardness without brittleness, eliminate warping, and add extra toughness and resistance to abrasion.

And that's why *all* leading implement makers equip their tillage tools with Ingersoll discs as standard equipment. To be sure of the same original equipment quality in the replacement discs you sell, order Ingersoll discs direct from *your* implement maker.

Ingersoll *Heat Treated* **Discs**

Ingersoll

ENGINEERING B-W PRODUCTION

PRODUCTS DIVISION

BORG-WARNER CORPORATION

Chicago 43, Illinois

SPECIALISTS IN TILLAGE STEELS • WORLD'S LARGEST MANUFACTURER OF DISCS

AGRICULTURAL ENGINEERING

VOL. 37 MAY, 1956 NO. 5

New Experimental Techniques Accelerate Farm Equipment Design Development

R. J. Miller and M. A. Erickson

The authors use the development of the engine-block attachment to the front pedestal of a new tricycle-type tractor to illustrate application of Stresscoat and strain-gage techniques in accelerating design development

EXPERIMENTAL strength analysis techniques using Stresscoat* and strain gages are now being used successfully to accelerate the development of tractors and farm equipment. Certain general procedures are usually followed. Service loads are measured accurately under simulated field conditions. (Service loads are those loads actually encountered under field conditions.) Working stresses are then located and evaluated in the laboratory. (Working stresses are the stresses resulting from service loads.) The allowable stress of the material is either measured in the laboratory or found from text references. (The allowable stress is that amount of stress that is considered safe or permissible in the material used.) The factor of strength of the design is then obtained by comparing the allowable stress to the working stresses obtained from measured service loads.

The development of the engine-block attachment to the front pedestal of a new tricycle tractor may be used to illustrate these experimental or laboratory techniques. A front pedestal that would be interchangeable with a four-wheel tractor front end was desired (Fig. 1).

In setting up the strength-analysis program, the first step was to consider the service or field loads. From our company implement engineers we obtained the necessary data on some of our front-mounted implements, such as weight distribution, method of attachment, structure, bracing, etc. From this information it was decided to use the four-row front-mounted planter for maximum vertical loadings, and to use the three-row middlebuster for lateral bending loads on the tractor structure. Planter loads were simulated with a test fixture (Fig. 2). The middlebuster loads were applied by adapting a standard implement to our test tractor (Fig. 3).

The test procedure for each of the field loadings considered followed this general plan:

- Selection and preparation of the test course.
- A pretest shakedown run over the test course.
- A run over the test course using the Stresscoated parts under study, to be followed by a study of the Stresscoat patterns to determine location and direction of strains, as well as nature and direction of the applied loads.
- Load calibrations are then made using SR-4 strain gages cemented in the critical areas. Loads are applied in previously determined directions up to a magnitude not exceeding the yield point of any strain-gaged area.
- From previous calibration tests, strain gages are selected that are sensitive to a particular direction of loading. Field tests are then run, measuring the strains on the selected gages by means of a multichannel oscillograph.
- Convert the measured strains to load, and record load direction, magnitudes, and frequency of application. This is known as *load analysis*.
- Apply known loads to the test part using laboratory fixtures. Measure strains in all critical areas by means of strain gages, extensometers, etc. These strains are converted to stress by applying the proper formula and material relationships. The resulting stresses are known as the working stresses. This process is known as *stress analysis*.
- Determine the allowable stress of the material by means of fatigue tests on the part or data from published texts. This is known as *material analysis*.
- Compare the working stress to the allowable stress to evaluate the factor of strength of the design. This completes the *strength analysis* of the design.

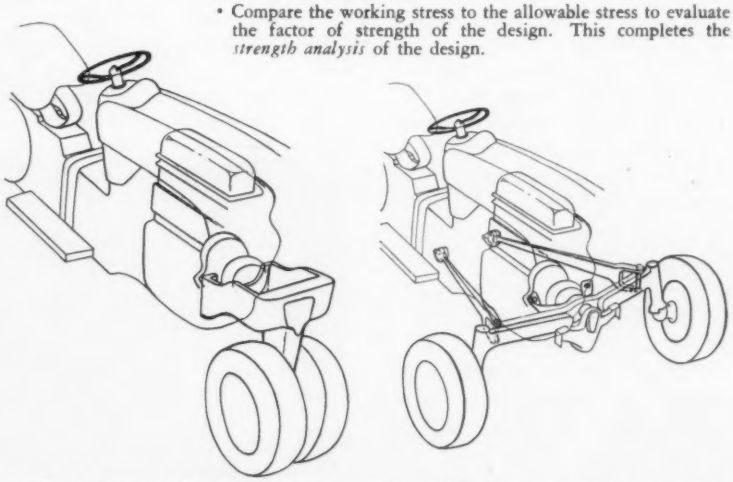


Fig. 1 Front pedestal designed for interchangeability between tricycle-type and four-wheel-type tractors

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1955, on a program arranged by the Power and Machinery Division.

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*Stresscoat is a product of Magnaflux Corp., Chicago, Ill.

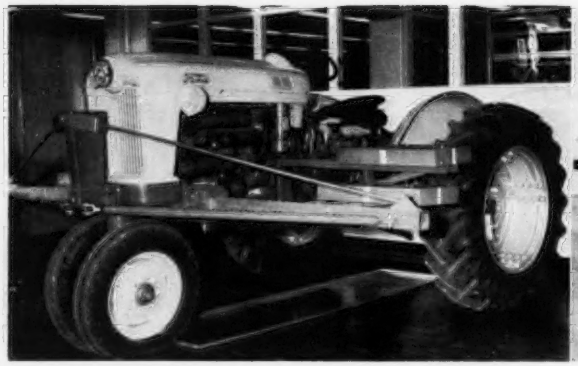


Fig. 2 *(Left)* Test fixture affixed to front of tractor to simulate front-mounted planter loads • Fig. 3 *(Right)* Middlebuster loads were applied by standard implement

The field test program included two kinds of loadings as follows:

- Transport loadings—produced by four-row front-mounted equipment moving over land worked with a middlebuster to represent transport across fields.
- Draft loadings—produced by front-end-mounted middlebusters in operation.

The above-stated conditions were considered as providing all of the maximum stresses that the front end of a tricycle tractor might encounter.

A field was prepared to provide rough transport conditions for the planter. Areas were selected for the middlebuster test. These areas ranged in severity from normal stubble to soddy and stony ground to wooded conditions having roots and stumps.

An all-weather evaluation center (Fig. 9) has recently been constructed to provide these test conditions as well as a variety of other test conditions for future programs. Here the simulated loadings can be reproduced exactly the same year after year.

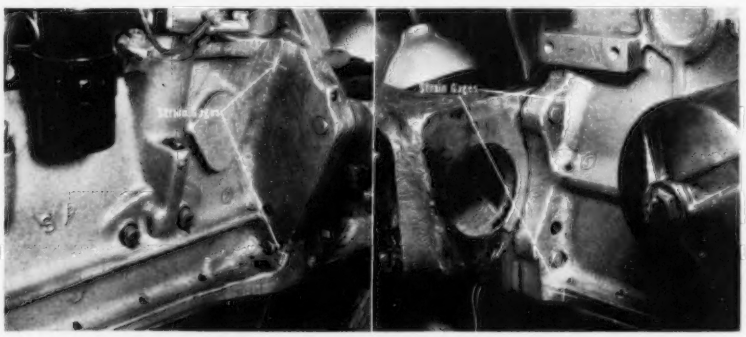
The test-course preparation was followed by a shakedown run of the tractor with the loading equipment in place. This run is made prior to Stresscoating the parts. The purpose of the shakedown run is to relax the assembly and residual stresses in the parts under study. This permits the Stresscoat test to register only the active strains that are imposed by external loads. In accordance with this practice, shakedown runs were made on the experimental tractor before each of the Stresscoat tests.

Stresscoat tests were made on the tricycle front end using the planter and middlebuster loadings on the test courses described above. The tractor with its simulated planter was run across the middlebusted furrows at right and oblique angles. The load patterns that resulted could be duplicated in the laboratory by means of vertical, side, and fore-and-aft pedestal loadings.

The entire front end structure was Stresscoat tested, including the pedestal, engine block, and transmission case. For the purpose of this paper, however, only the engine-block front-attaching flange is treated.

The Stresscoat patterns obtained during the field test are shown in Figs. 4 and 5. It was desired to measure loads at the engine-block front attachment in three directions. These included fore-and-aft, side, and vertical loads. This was accomplished by applying the strain gages on the top and bottom positions on both sides of the block and also on the front spindle. The strain gages on the engine block were placed at right angles to the Stresscoat indications and read separately. The four gages on the spindle were connected in a bridge circuit to measure vertical reaction only. Gage readings were taken for each of the three directions of loads. Loads were applied using laboratory fixtures and making certain not to yield any part of the structure during the calibration run. Side loads and fore-and-aft loads were applied to the front tires just above the ground-contact point by means of a hydraulic ram. The magnitude of the loads was determined by hydraulic-pressure readings. The tractor was anchored at the extreme ends of the rear axle for this test. Vertical load was applied by means of a drop test, and strains were recorded on a Consolidated optical-type oscillograph (Fig. 6). Also, a static vertical-load calibration was made of the front spindle. Thus it was possible to correlate height of drop with front end vertical load as measured in the field.

Following these load-calibration tests, field tests were made on the course described above. The strain gages were read simultaneously on a 6-channel Brush oscillograph mounted in a four-wheel-drive instrument truck, referred to



Figs. 4 and 5. Stresscoat patterns obtained during the field test are shown in areas near location of strain gages (indicated by arrows)

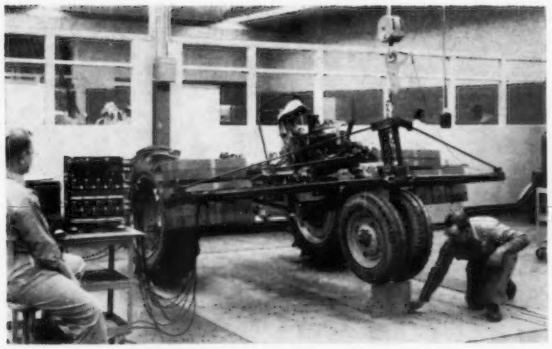


Fig. 6 Laboratory test fixtures were used for applying fore-and-aft, side, and vertical loads. Strains were recorded on an optical-type oscillograph

as the travelab. Thirty-foot leads were used between the tractor and travelab. The travelab instrumentation is powered by a 1500-watt, 110-volt a-c- Homelite engine generator.

The oscillograms obtained from the field test were analyzed and compared to the laboratory calibrations to determine the following service load data: *(a)* direction of applied loads, *(b)* maximum magnitude of applied load, *(c)* significant excursion or range of applied load, and *(d)* frequency of applied load.

With the load data available it was now possible to make a stress analysis of the engine-block front-flange area. The tractor was mounted on test fixtures in the laboratory, and service loads applied. Principal strains were measured using SR-4 X gages. One leg of the gage was oriented at right angles to the Stresscoat indications previously produced. The other gage was located perpendicular to this one and parallel to the indications. These strains are converted to principal stresses using the following formulas:

$$S_x = \frac{E}{1-\mu^2}(e_p + \mu e_q) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

and

$$S_y = \frac{E}{1-\mu^2}(e_q + \mu e_p) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

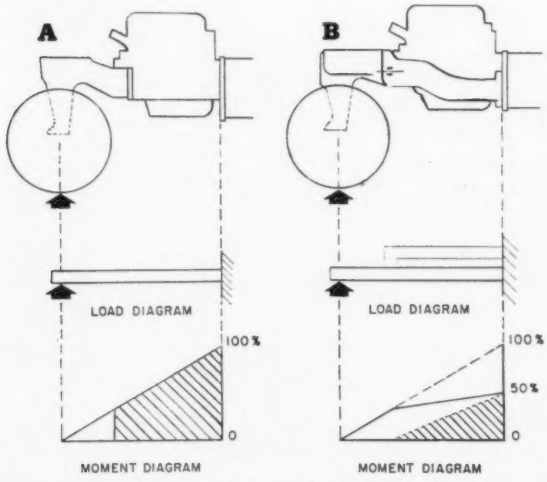


Fig. 7 Load and moment diagrams for front-end vertical loading with (diagram B) and without (diagram A)

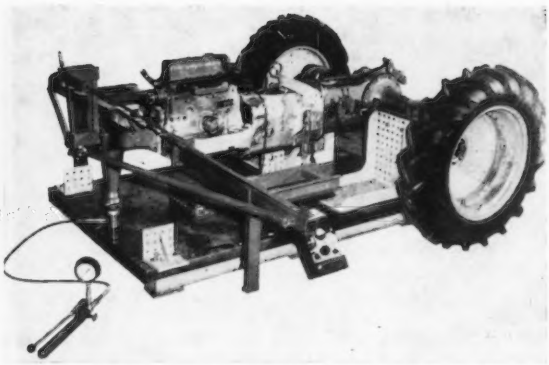


Fig. 8 Apparatus for measuring front-wheel loads and bending moments carried by the engine block and side rails

where S_x = major principal stress perpendicular to Stresscoat indications (psi)

S_y = minor principal stress parallel to Stresscoat indications (psi)

e_p = measured major principal strain perpendicular to Stresscoat indications (inches per inch)

e_q = measured minor principal strain parallel to Stresscoat indications (inches per inch)

μ = Poisson's ratio

E = modulus of elasticity (psi)

These stresses, known as working stresses, are then tabulated according to direction of applied load, stress range, and frequency of occurrence. An attempt is made here to estimate the total number of times the significant stress range will occur in the life of the tractor.

In proceeding with the test on the engine block it was necessary to determine the allowable stress of the cast-iron material used. Since many of the loads were fluctuating in nature the fatigue strength had to be determined. In this case, fatigue data taken from tests made on a similar material was used (2)† The allowable stress for the anticipated life was determined by using the stress life curve and the modified Goodman diagram.

The allowable stress of the material was compared to the applied stress as measured in service loads. It was found that maximum loads could be carried for only a short period of time on the engine block front attaching flange of the experimental tractor. A study of the life curves of the material and of the stress applied suggested that the engine block should be required to carry approximately one-half of the entire load. To do this, side rails between the front pedestal and the transmission case might be added, to take the other one-half of the load.

The load and bending-moment diagrams for the tractor with and without side rails are shown in Fig. 7. Diagram A shows the case where the engine block must carry the entire bending moment, while in diagram B the engine carries a much smaller proportion of the total bending moment. The shaded portions of the diagram represent the bending moment carried by the engine block. The side rails, therefore, would carry the difference that is shown by the unshaded area in diagram B. A similar analysis was made to determine the strength needed in the side rails for lateral loading.

†Numbers in parentheses refer to the appended references.

Fig. 9 The tractor at the right is being driven over the all-weather evaluation center. Strain gages are read simultaneously on an oscillograph mounted in the instrument truck

Side rails of adequate strength were then designed using rubber bushings to attach the front end of the engine to the side rails. In structures where load is carried in parallel paths the load is divided between the paths in proportion to their stiffness. In our case the side rails are one of these paths and the engine block and rubber bushings the other. The rubber bushings reduce the stiffness of the path through the engine, thereby reducing the load carried by the engine. The flexibility provided by the bushings can be altered by varying rubber hardness to control the load transmitted through the engine.

The proper hardness of rubber bushing was determined by making laboratory tests on the assembled side rail design. Front wheel loads were applied and the individual bending moments carried by the engine block and by the side were measured (Fig. 8). Several bushings of various durometer were assembled and tested until an acceptable stress balance was obtained between the engine block and the side rails. The result obtained was a 50-50 bending moment distribution between engine block and side rails.

The new side-rail design was then tested thoroughly under controlled conditions in the laboratory. Stresscoat and strain gages were used to evaluate the factor of strength under service loads previously determined. On the basis of these tests the final recommendations were made. Once field loads are obtained all subsequent stress measurements can be made in the laboratory. The designs that are developed in the laboratory possess satisfactory strength for the particular loading conditions used.

It is not always possible to determine all the loads encountered by a machine in service from limited load measurements in one locality on a particular day and by a single operator. Since most of our equipment is used under a variety of ground conditions and by a variety of operators it is necessary to do some field testing to check structural strength. The field tests that are made have a two-fold purpose. Not only is structural strength checked but the performance of the experimental machines is evaluated. This requires operation under many field conditions.

To reduce development time to a minimum several experimental machines are built so that the laboratory tests and the field tests can be made concurrently. Many advantages are gained by conducting these tests at the same time. For example, a record of location and distribution of highly stressed areas can be passed on to the field test crews at an early date by means of Stresscoat photographs and reports. The field crews in turn can keep a close check on these areas and keep the laboratory informed.

In the case of the test described, side rails and rubber bushings of a specific durometer were recommended. This modification was made on field tractors. Field tests that followed bore out the laboratory findings, since no further failures were obtained in the parts under test. This is only one of many cases on file where design development has been accelerated and the design improved by using Stresscoat and strain-gage techniques.

With these laboratory techniques now available the structural strength of a machine can be checked in a matter of days. This reduces loss of time, and even an entire season, caused by failures of parts in development programs.

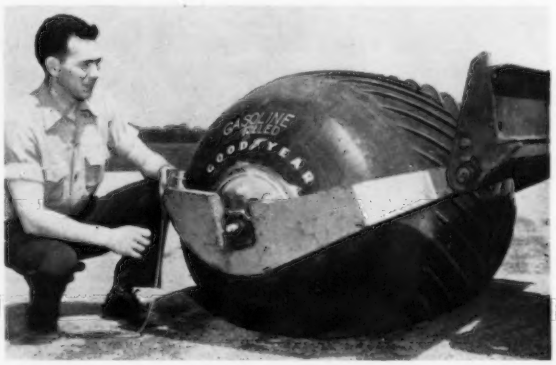
References

1 Perry, C. C. and Lissner, H. R. The strain gage primer, p. 131, Table 7-2. McGraw-Hill, 1955.

2 Erickson, M. A. Stress analysis of automotive cylinder blocks ASM Special Technical Publication No. 97, pp. 2-10, 1949.

Liquid Transport Tank

A WATERMELON-SHAPED rubber tank that rolls on the ground, floats in water, and can stand drops without bursting is expected to answer many problems dealing with the bulk transportation and storage of fuels and other liquids. The 3½ x 5-ft container is mounted on hubs and axles to permit easy handling. It can be towed manually or by vehicle. It is shown being coupled to a light truck prior to a test run.



Flotation characteristics are said to be excellent. Drawbar tests have indicated that only 30 lb of drawbar pull are needed to roll these storage units. The tanks weigh 40 lb deflated and have a capacity of 250 gal. Units can be towed either singly or in tandem behind any vehicle equipped with a trailer hitch without affecting the vehicle's gross weight. The low footprint pressures permit them to be drawn easily over unprepared surfaces, such as rocky, uneven terrain, swampy soil and sandy areas. The pliable construction of the tanks conform to the shape of obstacles over which they pass.

The manufacturer reports that the tanks, when filled properly, can be floated down rivers and across lakes. During recent company tests, fully-loaded tanks were dropped 15 ft without bursting.

Design of Above-Ground Horizontal Silos

M. L. Esmay, D. B. Brooker and J. S. McKibben
Member ASAE Member ASAE Assoc. Member ASAE

Lateral pressures in silage, including those occurring during packing, are the factors for which above-ground horizontal silos must be designed to withstand. A study of behavior of these pressures has provided important design criteria

HORIZONTAL silos will serve present-day farming operations best if they are economical and completely functional. To be completely functional they must be located conveniently, designed for minimum losses, and constructed for durability and long service. They should be adapted also for self-feeding or for efficient feeding by use of mechanical equipment.

Thousands of temporary unlined trench silos have been constructed during the last few years. Many of these have been located inconveniently because adquate sloping terrain was not available near the feedlots. On some farmsteads where a sloping terrain with adequate drainage is available near the feedlots a trench-type permanent silo can be constructed economically. In many cases, however, above-ground construction will be required.

The design and construction of economical and practical above-ground horizontal silos have created somewhat of a problem, since self-supporting walls are necessary. Until 1953 and 1954 when the initial research work was done at Missouri (1)* on silage pressures in horizontal silos, there was little design information available.

Purpose of Project

A new silo was designed, based on the results of the 1953-54 tests, and constructed on the University of Missouri, agricultural engineering experimental farm ten miles west of Columbia, in April, 1955. The purposes of this silo were *(a)* to field test the design based on previous experimental results, *(b)* to try out a new technique for building and setting up walls for above-ground silos, and *(c)* to make further measurements of the unit lateral pressures by use of a new type of pressure panel.

The purpose of the additional lateral pressure measurements to be found with a new panel were *(a)* to obtain more directly the unit lateral stresses of the silage during and after the silo filling operation, *(b)* to obtain more extensive pressure information with different forages and harvesting conditions, and *(c)* to check previous findings with a different type of testing equipment.

Concrete Wall Construction

The walls of a horizontal silo must be rigid, durable, airtight and preferably have some slope. Tilt-up concrete wall construction has proven very practical and economical for below-ground (2), where the earth is used to support the panels, and it was felt that it would be desirable to adapt a similar technique to above-ground construction. For above-ground construction, panel supports or pilasters are required.

The experimental silo was designed with 4-in concrete wall panels 6 ft high and 10 ft wide. The pilasters were designed for 10-ft spacing and constructed in place with reusable forms as shown in Fig. 3. The pilaster cross section is 6 x 18 in at the footing, tapering to 6 x 12 in at the top. All the taper is made on the inside edge to give a side slope to the walls of 1 in per foot of side height. Spread-type footings for the pilasters were poured first and allowed to cure. Exposed reinforcing rods were left protruding from the top of the footings to receive the pilaster. The pilaster

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The authors—M. L. ESMAY, D. B. BROOKER and J. S. MCKIBBEN—are, respectively, formerly professor of agricultural engineering at the University of Missouri now at Michigan State University and associate professor and assistant professor of agricultural engineering, University of Missouri.

* Numbers in parentheses refer to the appended references.

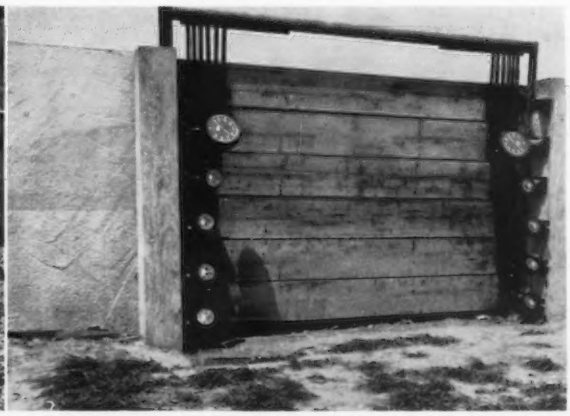

Fig. 1 *(Left)* Pressure test panel as seen from inside of silo • Fig. 2 *(Right)* Pressure test panel as seen from outside of silo. Panel consists of 12-in planks hung individually by an overhead pipe. Outward forces on the planks are measured by hydraulic cylinders and pressure gages

forms then were placed over the reinforcing on the footings and filled with concrete.

After the pilasters have been constructed, edge forms for the floor are placed 5 in inside of the pilasters. This allows space for the wall panels to set down on the footings between the floor and the pilasters. Reinforcing mesh is then placed and the concrete poured for the floor. The pilaster footings project under the floor and the pilasters are designed as a cantilever type.

The following day after the floor is placed, edge forms for the wall panels can be constructed, reinforcing placed, and the panels poured. The wall panel reinforcing must be near the outside surface when the panel is in the upright position. Reinforcing is also required near the bottom surface of the panel as it is lifted into place. For these reasons all of the reinforcing was placed near the bottom surface. The panels were picked up with a wrecker by the edge nearest the pilasters (Fig. 4) and moved into an upright position against the pilasters. This operation could be done with the heavier farm tractors equipped with lifts.

A silo 20 ft wide and 6 ft deep constructed with this design will cost approximately $4.00 per ton of silage storage capacity for materials. This is figuring concrete at $13.00 per cubic yard and reinforcing steel at 10 cents per pound. Labor costs will vary but are minimum with this type of construction where none of it is much more complicated than pouring a flat slab of concrete.

Pressure Panel

In place of one of the concrete wall panels, a pressure panel was constructed as shown in Figs. 1 and 2. The pressure panel was constructed of independent horizontal planks so that unit pressures could be measured at each foot of height during the filling operation. Each plank was 11½ in wide and was individually suspended from above on flexible straps. Both ends of the planks were supported horizontally with hydraulic cylinders and pressure gages as shown in Fig. 2. One-half inch of clearance was provided between all planks, and roll roofing was placed on the inside surface of the planks as shown in Fig. 1.

Each plank had a pressure area of 10 sq ft and the total load was indicated by the two gages. For unit pressure readings at each foot of silo height the total of the two gage readings on each plank was divided by 10. Two readings were recorded from each gage after each load of forage was added to the silo. One reading was taken for the packed silage without a packing tractor on the silo and another as the packing tractor passed within an inch of the edge of the silo.

Test Conditions

The silo was filled the last two weeks of May, 1955, with field-chopped wheat silage. The wheat was cut with a direct-cut, flail-type forage harvester. The wheat forage was unloaded and spread in the silo with rear-end unloading wagons. The wheat had headed and the kernels were developing from the milk into the dough stage. The forage was not chopped in uniform lengths as it might come from a conventional chopper, but was well broken up and had a moisture content of about 70 percent.

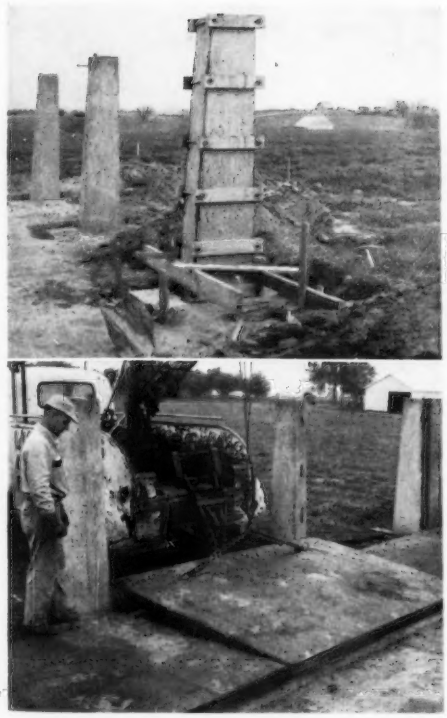

Fig. 3 *(Top)* Removable forms used to cast pilasters • Fig. 4 *(Bottom)* Wall sections can be hoisted into place. Reinforcing steel mesh is placed nearest outside edge of wall

A farm tractor was used to pack the silage and was operated continuously during the silo-filling operation.

Findings and Analysis

When the first foot of silage was placed in the silo the bottom plank was put under stress. As the depth of silage increased to 2 ft the bottom two planks were under stress and

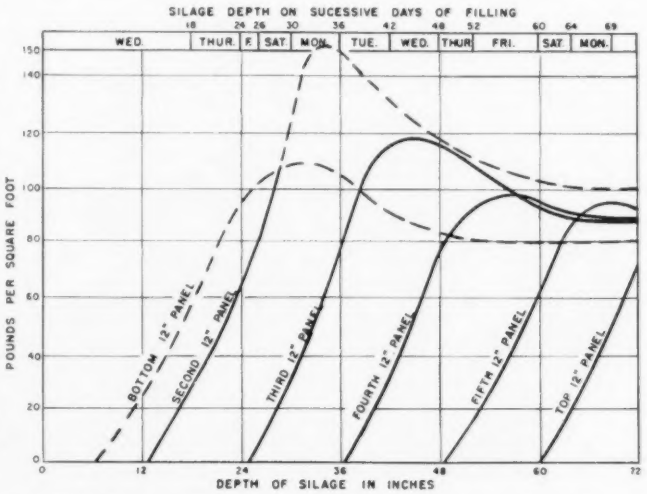

Fig. 5 Lateral unit pressure on each 12-in panel throughout the silo filling operation

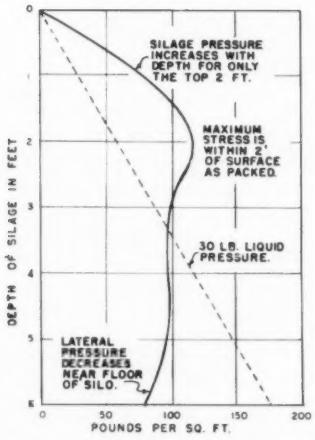

Fig. 6 Lateral unit pressure on silo walls soon after silo has been filled

so forth, up to 6 ft, when all six planks were under stress.

The pressure readings taken during the silo-filling operation provide a complete picture of the unit pressures at each depth. These pressures are illustrated graphically in Fig. 5. The graph shows that the unit pressure of each plank, except the bottom one, increased quite uniformly as the level of silage went up from the bottom to the top edge of each plank. Although the pressure on each plank actually is not unit pressure until the entire plank is covered, it has been recorded as such.

A firm pack of forage was not obtained in the silo during the first day of filling. The depth at the end of the day was recorded as 18 in, but compared to the compacted depths recorded during the rest of the filling operation, the amount of silage placed in the silo that day should have packed to about 12 in. This discrepancy moves the curve for the bottom panel to the right in Fig. 5 and for that reason it is shown as a broken line.

The unit pressure on each plank reached a maximum as the silage level increased up to one foot above the plank.

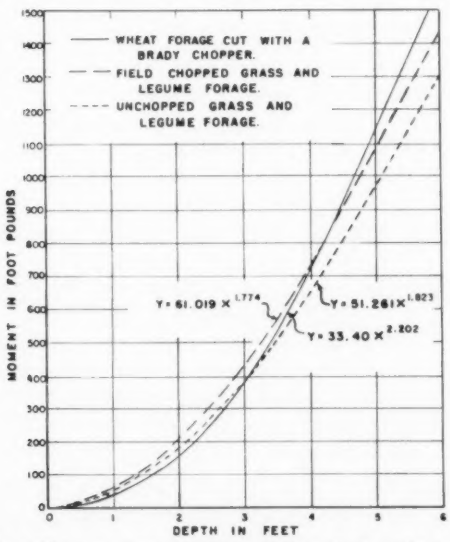

Fig. 7 Silage overturning moment per foot of silo wall length.

These data indicate that the top two feet of silage, as the silo is filled, is packed in excess of what the internal friction of the material will retain. Therefore, as the silage level increases beyond a foot above each plank, the unit pressure is relaxed. As is indicated by the curves of Fig. 5, the unit pressures all relaxed down to approximately 100 lb per sq ft.

The pressure on the second plank from the bottom reached a maximum at a considerably higher pressure than any of the others. As indicated by the filling schedule shown on the top part of Fig. 5 the rate of filling was quite slow from the two to the three-foot level. The filling operation was halted both Friday and Saturday afternoons because of rain. Even though little forage was added, considerable packing was done and the rain helped make the packing tractor more effective. No packing or filling was done over Sunday, although an additional inch of rain fell to help settle the silage even more. It is believed that these conditions caused the abnormally high peak of 155 lb per sq ft for the unit pressure of the second plank from the bottom and for these reasons the upper portion of the curve is shown as dotted.

The curves of Fig. 5 show that a single-unit pressure curve for the total depth of silage would change throughout the silo filling operation. In general the unit pressure is at a maximum approximately two feet below the silage surface. At depths below this peak the pressure levels off at approximately 100 lb per sq ft.

Fig. 6 shows the shape and magnitude of a unit-pressure curve for silage soon after the silo is filled. After a period of several hours the excess pressure at the two-foot level relaxes until the pressure curve is practically vertical. The pressure curve turns in at the bottom of the silo due to the friction of the silage on the floor. This is indicated in Fig. 5 by the lower pressures on the bottom plank throughout the filling operation. It is interesting to note in Fig. 6 the contrast between the pressure curve for a liquid equivalent of 30 lb per cu ft and that for silage soon after being packed.

Overturning Moment Caused by Silage Pressures

The overturning moment is required for the design of pilasters and other lateral supports for the walls of above-ground horizontal silos. Fig. 7 illustrates the three moment curves obtained from three successive years of testing (1953, 54 and 55). As reported in AGRICULTURAL ENGINEERING (1) the tests made in 1953 were with long grass and legume

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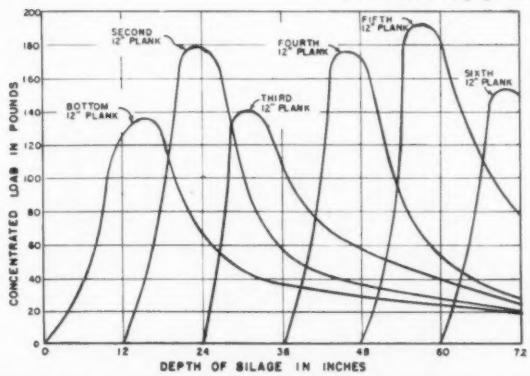

Fig. 8 Lateral concentrated loading of packing tractor throughout silo filling operation

Longitudinal Stability of Tractors

Hans W. Sack
Assoc. Member ASAE

Derivation of a new criterion for longitudinal stability opens door to a new method for rapid analysis of stability performance of any wheel-type tractor and shows promise of being a valuable aid to tractor and implement designers

THE stability of wheel-type farm tractors has been discussed ever since E. G. McKibben's classic investigation was presented in 1927 (1)*. Since World War II great numbers of light tractors with high horsepower engines, compared to prewar tractor models, have been produced. The increased horsepower-to-weight ratio of these tractors required close attention to stability problems. A later paper by W. H. Worthington (2) outlined both lateral and longitudinal stability problems and showed their solutions. In this paper it was stated that almost all cases of tractor backward upsets occurred when the tractor was unhitched from the implement and the rear wheels lodged in soft ground, or when the tractor was pulling an improperly hitched load, for example, pulling with a chain attached to the rear-axle housing. While the hazard of upsetting the tractor when pulling a properly hitched load on an incline is practically non-existent, it is important to know whether or not the tractor can become unstable, *i.e.*, whether the front wheels will leave the ground and steering be rendered impossible. This will happen only when the angle of the incline upon which the tractor is operated becomes greater than the critical angle of dynamic stability. Worthington defines it (2) as the angle of the maximum inclination which the tractor may ascend under maximum drawbar load, measured as the weight of the front wheels on the ground becomes zero.

A further investigation of longitudinal stability problems of tractors pulling properly hitched loads uphill is presented in this paper. In particular, a new method of evaluating the critical angle of longitudinal stability will be presented and the factors affecting the critical angle of longitudinal stability discussed. Also the kinematics of the tractor at the instant when the front wheels leave the ground will be considered.

Worthington (2) analyzes the longitudinal stability of wheel tractors by considering the tractor as a "free body" (Fig. 1). The following assumptions apply at the instant the tractor becomes unstable:

- There is no weight on the front wheels; hence $W_{nf}=0$.
- Since $W_{nf}=0$, there is no rolling resistance at the front wheels, and therefore $R=0$.
- The tractor is considered to be on a hard surface so that the reaction on the rear wheels is directly beneath the rear-axle center and at the contact surface. Digging in of rear wheels as a result of slippage is neglected.
- There is a sufficient amount of torque available at the rear axle so that drawbar pull is limited only by the value of the traction coefficient and the weight of the tractor.
- Drawbar pull is parallel to the ground and is the maximum possible value for the conditions under consideration.

Following are the equations for the moments of stability and instability:

Moment of Stability

$$M_s = W\,(L_{cg}\cos\beta - H_{cg}\sin\beta) \quad [1]$$

Moment of Instability

$$M_I = P_1 H \quad [2]$$

where $P_1 = \mu W_{nr} - W\sin\beta - R$

$$= \frac{\mu W(L_2\cos\beta + H_{cg}\sin\beta) - W_b(W\sin\beta + R)}{W_b - \mu H} \quad [3]$$

where W = operating weight of tractor with operator (pounds)
β = angle of gradient (deg)
L_{cg} = distance of center of gravity ahead of rear-axle center line (inches)
H_{cg} = height of center of gravity above ground level (inches)
L_2 = distance of center of gravity back of front-axle center line (inches)
W_b = wheelbase (inches)
W_{nr} = normal ground reaction at rear wheels (pounds)
W_{nf} = normal ground reaction at front wheels (pounds)
F_t = tractive effort (pounds)
H = height of drawbar above ground level (pounds)
μ = traction coefficient (dimensionless)
P_1 = drawbar pull (pounds)

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Acknowledgment: The initial work on this project was done by J. A. Hilgendorf.

*Numbers in parentheses refer to the appended references.

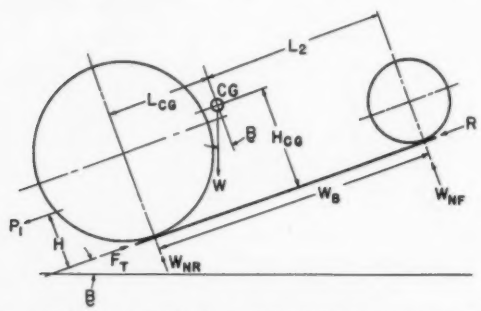

Fig. 1 Free-body diagram of a rubber-tired tractor on a grade

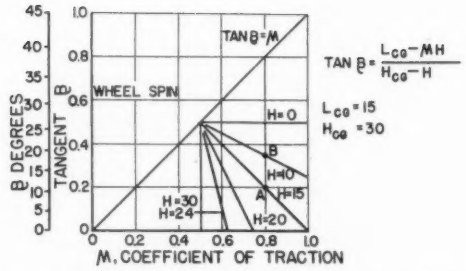

Fig. 2 Relation between critical angle of dynamic stability, critical angle of static stability, traction coefficient and drawbar height

The critical dynamic stability angle may be calculated by solving equations [1] and [2] simultaneously. The moment of stability is equal to the moment of instability, and, furthermore, the rolling resistance of the front wheels, R, becomes zero. It is the usual practice to determine the critical dynamic stability angle by substituting all numerical values for one particular tractor in equations [1], [2] and [3] and then solving for this angle. This is a rather tedious and time-consuming procedure, if many tractors or many conditions for one tractor are to be analyzed. It has been found that a considerable simplification of this process is possible, by first solving the equations algebraically and then substituting numerical values. Equations [1], [2] and [3] can be solved as follows:

Equation [3] is substituted in equation [2].

Then
$$M_1=\left[\frac{\mu\, W(L_2\cos\beta+H_{cg}\sin\beta)-W_b\, W\sin\beta}{W_b-\mu H}\right]H \quad [4]$$

Note that R does not appear, since when $W_{nf}=0$, $R=0$. Equating the stability moment to the moment of instability,

$$M_s=M_1,\ W(L_{cg}\cos\beta-H_{cg}\sin\beta)=\left[\frac{\mu\, W(L_2\cos\beta+H_{cg}\sin\beta)-W_b\, W\sin\beta}{W_b-\mu H}\right]H$$

This reduces to

$$\tan\beta=\frac{W_b\, L_{cg}-\mu H L_{cg}-\mu\, HL_2}{W_b(H_{cg}-H)}$$

but $L_2=W_b-L_{cg}$, which, substituted in the foregoing expression, facilitates still further reduction, such as

$$\tan\beta=(L_{cg}-\mu H)/(H_{cg}-H) \quad . \quad . \quad . \quad . \quad . \quad [5]$$

Thus it can be seen that the critical angle of dynamic stability is a function only of the traction coefficient (μ), the location of the center of gravity with respect to the ground (H_{cg}) and the rear axle center line (L_{cg}) and the height of the drawbar above the ground (H).

Equation [5], though rather simple, is highly important for all considerations of longitudinal stability. As shown in the following paragraphs, much valuable information can be derived from this equation, and it facilitates a better understanding of tractor stability. By means of this equation the longitudinal-stability performance of any existing or proposed tractor design can be evaluated more readily than by the previous method. The stability characteristics of one tractor, which has been proven satisfactory, can be compared accurately to a proposed model. This equation also allows an accurate evaluation of all the factors affecting the critical angle of dynamic stability, which is the important criterion for longitudinal stability.

Equation [5] covers the entire theoretical range in which all the values vary from negative to positive infinity. Only a limited part of this theoretical range represents actual conditions. These limitations are pointed out as follows:

- Slopes practically encountered in tractor operation have angles less than 45 deg.
- The coefficient of traction has not been found in excess of 0.83. Even this value can be found only when operating the tractor on concrete or specially prepared test tracks. In the report on work conducted on the SAE tractor tire test program (3) values of traction coefficients as high as 0.8 were found when the slippage was well in excess of 60 percent. For normal farming operations under favorable conditions, 0.75 is the maximum value of traction coefficient.
- If the coefficient of traction is less than the tangent of the slope angle, the tractor will spin its wheels or slide down the slope. Thus equation [5] can be used only for stability considerations if tan β is less than μ.
- The ratio of the distance of the center of gravity ahead of the rear axle center line (L_{cg}) to its height above the ground (H_{cg}) is the tangent of the static stability angle. In practice this angle is limited to a rather small range of approximately 33 to 47 deg as was found by a survey of a number of current farm tractors without wheel weights. As soon as rear-wheel and front-end weights are used, this range will change. Particularly if a great number of rear-wheel weights are mounted on the tractor without the balancing effect of front-end weights, the static stability angle will decrease considerably.
- The available torque at the rear axle must be great enough so that the drawbar pull is limited by rear-wheel traction only. Of course, it is also possible to raise the front end of the tractor by locking the rear wheels and pulling on the drawbar, provided all other conditions are favorable.

In order to make equation [5] and its limitations more easily understandable, it is represented graphically in Fig. 2. The tangent of β and the coefficient of traction μ are plotted on the vertical and horizontal axes, respectively. The line tan $\beta=\mu$ divides the graph so that the area above the line represents conditions under which wheel slip or spin would prevent a tractor under no load from climbing a slope steep enough to become unstable. Conversely, the area below the line represents conditions under which traction is

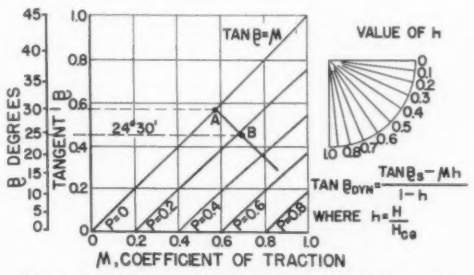

Fig. 3 Graph for predicting dynamic stability angles

sufficient to allow a tractor under load to ascend a slope steep enough so it may become unstable. Equation [5] with values for any particular tractor is represented in the graph as a line which will be referred to as the stability performance line.

In Fig. 2 the following values have been chosen as an example: distance of center of gravity ahead of the rear-axle center line $L_{cg}=15$ in; height of center of gravity above the ground, $H_{cg}=30$ in, therefore, the tangent of the static stability angle tan $\beta_{static}=0.5$ and $\beta_{static}=26$ deg 30 min. Lines for various drawbar heights, H, are shown. If the tractor has a drawbar height of 15 in and pulls the maximum possible load uphill on a surface where the traction coefficient $\mu=0.8$, the critical dynamic angle of such slope will be 11 deg 20 min, or tan $\beta=0.2$, point A. If the drawbar height is decreased to $H=10$ in, the critical dynamic stability angle will be $\beta=19$ deg 20 min or tan $\beta=0.35$, point B. Increasing the height of the drawbar to $H=20$ in will allow the tractor to become unstable even on level ground. These considerations hold true only if the tractor is pulling the maximum load which, of course, will vary with μ, β, and the weight of the tractor.

From this graph it can be seen that the critical angle of dynamic stability for any tractor varies linearly with the traction coefficient. Thus the statement that any one tractor has a certain critical stability angle cannot be made unless the traction condition of the surface on which the tractor is operated is specified. This very important point renders obsolete the frequently held opinion that the stability performance of a tractor can be measured by its critical dynamic stability angle. It is not one angle but the location and the slope of the stability performance line in Fig. 2 which facilitates the complete evaluation of the stability performance of a tractor.

In order to make more general use of equation [5], it can be rewritten after introduction of the following terms:

$$\tan \beta_{static}=L_{cg}/H_{cg}$$

$b=H/H_{cg}$ or is a ratio between drawbar height and height of center of gravity. Equation [5] is transposed by dividing by H_{cg}

$$\tan \beta=\frac{\frac{L_{cg}}{H_{cg}}-\frac{\mu H}{H_{cg}}}{1-\frac{H}{H_{cg}}}$$
$$=(\tan \beta_{static}-\mu b)/(1-b) \quad . \quad . \quad . \quad . \quad [6]$$

Equation [6] as represented in Fig. 3 is particularly helpful in predicting tractor-stability characteristics. In Fig. 3 tan β and μ are plotted on the two axes in the same way as in Fig. 2. A series of lines with different slopes is drawn representing various values of the drawbar-center of gravity height ratio b. The critical dynamic stability angle for any tractor under any traction condition can be found in the following way: Assume a tractor has a static stability angle of 30 deg, its drawbar is half as high as the center of gravity, and it is operating on soil with a coefficient of traction of 0.7. Find the intersection of the line tan $\beta=\mu$ and the tan 30-deg line at A. Draw a line with the slope given under $b=\frac{1}{2}$ through A. The intersection of this line with $\mu=0.7$ at B is the critical dynamic stability angle 24 deg 30 min.

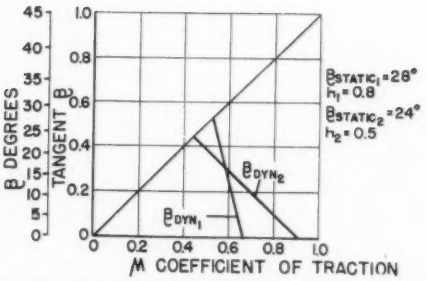

Fig. 5 Graph comparing two tractors with different drawbar-center of gravity height ratios

It is evident that the maximum drawbar pull will change its magnitude as the angle of the slope and the traction coefficient vary. The ratio between drawbar pull and total tractor weight can be derived from equation [3]:

$$P_1=\mu\ W_{nr}-W\ \sin\ \beta-R$$

When the tractor reaches unstable conditions

$$P_1=\mu\ W\ \cos\ \beta-W\ \sin\ \beta$$
$$P_1/W=\mu \cos \beta-\sin \beta=(\mu-\tan \beta)\ \cos\ \beta=p$$

Lines representing various drawbar pull to weight ratios p are shown in Fig. 3.

By means of equation [5] the critical dynamic stability angle can be found geometrically for any traction coefficient. Fig. 4 showing a scale drawing of a tractor is self-explanatory.

Equations [5] and [6] show the factors which influence the magnitude of the critical angle of dynamic stability. It is readily apparent that a tractor is more apt to become unstable on a surface with good tractive conditions than on a slick surface. In other words, the greater the coefficient of traction, the smaller the critical dynamic stability angle. It is impossible to render a tractor unstable on an icy surface no matter what the slope of the surface. While the traction coefficient is a given value determined only by the type of surface and the nature of the wheels employed on the tractor, other factors influencing the critical dynamic stability angle are inherent in the design and the equipment — additional weights and drawbar adjustment — of the tractor. These factors are the location of the center of gravity and the height of the drawbar. In equation [6] these factors enter as the static stability angle and the ratio between drawbar height and the height of the center of gravity. The tractor with a greater static stability angle will have a better dynamic stability performance provided all other factors are equal. The addition of rear wheel weights and liquid in the tires changes the static stability angle considerably. The

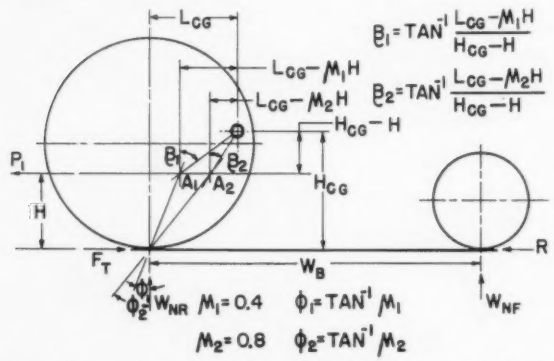

Fig. 4 Diagram showing geometrically the effect of variation in traction coefficient

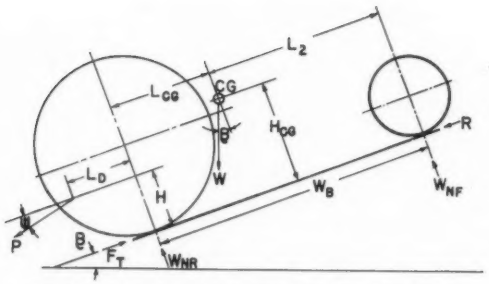

Fig. 6 Free-body diagram of a tractor on a grade. Drawbar pull has vertical component

wheel weights added for Nebraska tests F, G, and H decreased the static stability angle of five large standard-tread tractors an average of about 9.5 deg. By means of front end weights, the static stability angle can be kept within reasonable limits. Worthington (2) found that tractors with a minimum static stability angle in excess of 38 deg have satisfactory longitudinal stability. This statement coincides with information which can be obtained by reviewing Fig. 3. The point for 38 deg on the line tan $\beta = \mu$, which is the initial point for the stability performance line, is located on the abscissa $\mu = 0.78$, which is just above the range of traction coefficients encountered under normal farm operations. Most modern farm tractors fulfill this requirement or at least come close to it as long as no additional weights are used. But increasing the tractor weight as is done in Nebraska tests F, G and H will decrease the static-stability angle in some cases to a value as low as 28 deg.

The tractor having a static-stability angle greater than 38 deg cannot become unstable under normal farming operations as described above, no matter what the drawbar-center of gravity height ratio. This of course is true only as long as the center of gravity is higher than the drawbar, which is always the case when the drawbar load is properly hitched. On the other hand, the drawbar-center of gravity height ratio becomes an important factor for the tractor with a smaller angle of static stability. This is demonstrated in Fig. 5. Two tractors are chosen to have the following values:

	Tractor No. 1	Tractor No. 2
Angle of static stability, β_{static}	28 deg	24 deg
Drawbar—center of gravity height ratio, b	0.8	0.5

Assuming that both tractors have the same drawbar height, tractor No. 1 represents a low center of gravity, standard tread type tractor, while tractor No. 2 with a high center of gravity represents the row-crop type tractor with considerably greater ground clearance. The slopes of the stability performance lines in Fig. 5, determined by the ratios b_1 and b_2, give both tractors completely different stability characteristics. The characteristics of both tractors are such that they can become unstable under certain conditions. Tractor No. 1 with the greater static stability angle has a poorer stability performance on slopes up to 17 deg, yet on steeper inclines it will be superior to tractor No. 2. Tractor No. 2 with the smaller stability angle has a satisfactory stability on slopes below 8 deg, since its stability performance line falls outside the range of possible traction coefficients. The data chosen for both tractors are somewhat extreme, but they clearly indicate the important influence of the drawbar-center of gravity height ratio. Particularly tractors with low centers of gravity when carrying rear-wheel weights require close attention to their drawbar arrangement.

The relation between the critical angle of dynamic stability and the above mentioned factors has been established by purely theoretical considerations. It must be realized that any theory approaches practice only to a certain degree. Hardly any law of physics will exactly represent actual conditions, still extremely valuable information can be obtained if all the limitations and the deviations of practice from theory are recognized. In the case of dynamic stability of farm tractors, the deviations have been outlined as assumptions, which were made to derive equation [5]. It was said that any digging in of the tractor wheels due to slippage is neglected. However, it is known from experience that a considerable amount of slippage or travel reduction will occur if values of traction coefficient should be great enough to render modern farm tractors unstable. In other words, under conditions where longitudinal stability becomes a problem, more or less severe digging in will be experienced. The amount of digging in depends entirely on the surface conditions. Digging in will impair the stability performance of the tractor in two ways. First, it drops the rear end of the tractor down and increases the angle between the tractor and the horizontal. Naturally, this will be felt more with a tractor with shorter wheelbase. Second, the contact area between tire and ground will increase and therefore the traction coefficient will increase. At the same time the actual drawbar height decreases, but this advantage will be greatly overbalanced by the ill effects of digging in. Thus it must be kept in mind that the resulting effect of digging in of the rear wheels will cause the actual critical stability angle to be smaller than the theoretical value.

Furthermore, it was assumed that the pull on the drawbar is parallel to the ground. This assumption holds true for the conditions where the tractor pulls a trailer or similar implement which has the hitch located at the same height as the drawbar. In the case of pulling tillage implements, such as plows, the drawbar pull will not be parallel to the ground, due to downwardly directed soil forces. Since the hitch point on the tractor normally is located behind the rear axle a downwardly directed drawbar pull will increase the moment arm of the moment of instability and therefore decrease the critical dynamic stability angle.

After introducing the new terms, namely, φ angle between direction of drawbar pull and the operating surface, degrees, and L_D, distance of tractor hitch point behind the

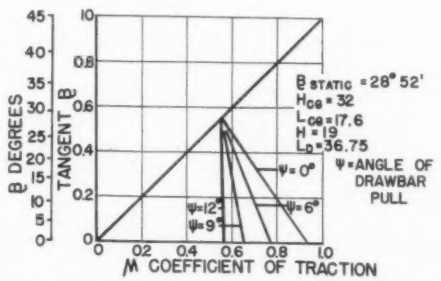

Fig. 7 Stability performance of a tractor with drawbar pull under various angles φ

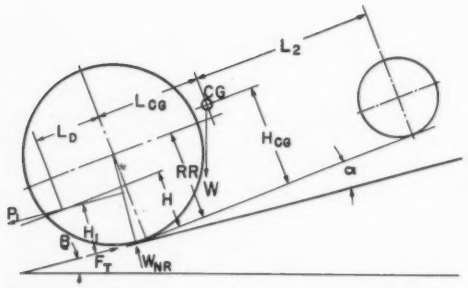

Fig. 8 Free-body diagram of a tractor on a slope after front wheels have left the ground

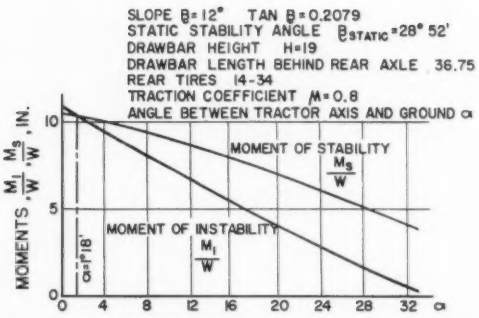

Fig. 9 Stability moments of tractor pulling maximum load uphill

rear axle, inches, and by derivation from Fig. 6 equations [2] and [3] will change to the following:

Moment of Instability

$$M_I = P_1 \cos\varphi\, H + P_1 \sin\varphi\, L_D \quad . \quad . \quad . \quad . \quad . \quad [2a]$$

Drawbar Pull

$$P_1 = \frac{W(\mu \cos\beta - \sin\beta) - R}{\cos\varphi - \mu \sin\varphi} \quad . \quad . \quad . \quad . \quad . \quad [3a]$$

Equations [5] and [6] then become:

$$\tan\beta = \frac{L_{cg}(\cos\varphi - \mu\sin\varphi) - \mu(H\cos\varphi + L_D\sin\varphi)}{H_{cg}(\cos\varphi - \mu\sin\varphi) - \mu(H\cos\varphi + L_D\sin\varphi)} \quad . \quad . \quad . \quad . \quad [5a]$$

$$\tan\beta = \frac{\tan\beta_{static} - \mu\, b'}{1 - b'} \quad . \quad . \quad . \quad . \quad . \quad [6a]$$

where $\tan\beta_{static} = L_{cg}/H_{cg}$ $\qquad b' = \dfrac{H + L_D \tan\varphi}{H_{cg}(1 - \mu\tan\varphi)}$

Equation [6a] indicates that the analysis made for equation [6] still holds true. Naturally an angled drawbar pull would not change the static stability angle of the tractor. The slope of the stability performance line is no longer determined by the ratio of drawbar-center of gravity height only. In Fig. 7 several stability performance lines are shown for one tractor. The distinction between these lines is that the angle of drawbar pull is different.

The drawbar pull with a downward vertical component has the same effect on the dynamic stability of the tractor as raising the drawbar when the drawbar force is parallel to the ground; it will decrease the stability considerably. The farther the hitch point is located behind the rear axle, the more this effect will be noticed. A greater angle between the drawbar pull and the horizontal will cause a smaller critical dynamic stability angle for any traction condition.

When plowing under normal conditions and with the plow hitch adjusted to an optimum, the drawbar pull angle will have a magnitude of about 12 deg. The tractor represented by the values in Fig. 7 has the hitch point farther to the rear of the rear axle than the average tractor. Therefore, the influence of angled drawbar pull is rather great. However, the stability performance of a tractor with average drawbar length is impaired considerably when angled drawbar pull is encountered.

After considering all the conditions under which a tractor can become unstable, *i.e.*, when the weight of the front wheels on the ground becomes zero, the following question is justified: What happens when the tractor has become unstable? As mentioned above, a tractor once having reached unstable conditions will not upset unless under extreme circumstances. Cases of upsetting tractors in this way have been very few.

Fig. 8 shows a free body diagram of a tractor after the front wheels have been raised off the ground. The tractor is operated on a slope with the angle β and the angle between the tractor and the surface is α. In order to analyze this situation it is assumed that the drawbar pull remains parallel to the ground in spite of the fact that the tractor hitch point is lowered. In this case equations [1], [2] and [3] can be rewritten as equations [7], [8] and [9], respectively.

Moment of Stability

$$M_s = W[L_{cg}\cos(\beta+\alpha) - (H_{cg} - R_R)\sin(\beta+\alpha) - R_R \sin\beta] \quad . \quad . \quad . \quad . \quad [7]$$

Moment of Instability

$$M_I = P_1\, H_1 \quad . \quad . \quad . \quad . \quad . \quad [8]$$

$$H_1 = R_R - (R_R - H)\cos\alpha - L_D \sin\alpha$$

$$M_I = P_1[R_R - (R_R - H)\cos\alpha - L_D \sin\alpha]$$

$$P_1 = \mu\, W_{nr} - W\sin\beta = \mu\, W\cos\beta - W\sin\beta \quad . \quad [9]$$

where R_R = rolling radius of rear wheels, inches

H_1 = height of tractor hitch point above ground, inches

α = angle between tractor and ground surface, degrees

L_D = distance between hitch point and rear-axle center line, inches.

Equations [7], [8] and [9] have been derived by means of geometry as shown in Fig. 8. It is evident that, if the angle α becomes zero, equations [7] and [8] will correspond to equations [1] and [2]. In Fig. 9 both moments divided by the weight of the tractor are shown graphically in respect to the angle α.

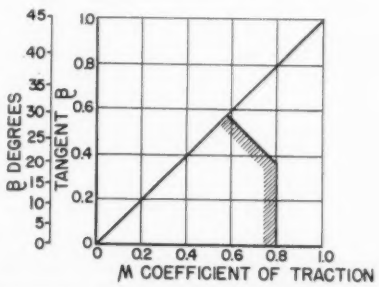

Fig. 10. Recommended limit of minimum stability performance for wheel-type tractors

The moment of instability decreases more rapidly than the moment of stability. The two curves intersect at $\alpha=1$ deg, 18 min. At this point the moments are equal in magnitude and the tractor is in equilibrium with its front wheels off the ground. In spite of the fact that the tractor is unstable, it will not upset. Conditions like this have been experienced by tractor operators many times.

Summary

In the analysis of longitudinal stability of wheel-type tractors as presented in this paper, a new criterion for stability has been derived and discussed. This criterion is the stability performance line represented in a chart in which the traction coefficient and the tangent of the angle of the incline are plotted on the axes. By means of these lines a rapid analysis of the stability performance of any tractor is possible. This method constitutes a new evaluation of the factors affecting stability as well as the problems involved. Particular attention has been given to the limitations of this theoretical method and to the existing deviations from practical conditions. All these deviations tend to decrease the dynamic stability to some extent.

To provide a background against which the results of a theoretical investigation may be evaluated, a survey has been made of the stability performance characteristics of a number of current tractors which in recent years have been sold in large numbers throughout the United States. From these data, it has been possible to prepare what might be termed a "recommended limit of minimum stability performance for wheel-type tractors," which reflects today's commercial trends. This is shown in Fig. 10. As long as the stability performance line of any tractor falls outside this limit, its stability level will be high. This high level may be justified by the need of allowing for contingencies such as angled drawbar pull and digging in of drive wheels. All tractors surveyed showed stability characteristics far beyond this limit on the safe side, as long as no wheel weights are used. The same tractors, weighted according to Nebraska tests F, G and H showed a completely different picture. All stability-performance lines came close to the limit and a small percentage was below.

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Design of Above-Ground Horizontal Silos

(Continued from page 327)

silage and in 1954 with chopped grass and legume silage. Curves for the 1953 and 1954 tests are illustrated by the broken lines in Fig. 7 and the curve for the 1955 test for wheat silage is shown as a solid line.

The curves show considerable similarity in shape and magnitude in view of the existing variables of different forages, different types of cuts, and different moisture contents. The best silage pack was obtained the third year with the wheat silage, and this is shown by the more rapid increase of the moment curve illustrated by the solid line in Fig. 7. Data from the moment curve for the 1955 tests are therefore considered to be the most reliable.

Stresses Caused by Packing Tractor

It will be noted that the unit stresses of Figs. 5 and 6 and the overturning moment of Fig. 7 are for the silage only, without the packing tractor on the silo, and these curves all represent data for conditions soon after the tractor was taken off the silo. Fig. 8 indicates that the tractor accounts for considerable additional stresses.

Fig. 8 is plotted similarly to Fig. 5 and shows the loads on each plank throughout the filling operation as the tractor was run within 1 in of the wall. The average concentrated load on any one plank ranged from about 135 to 195 lb. Of particular interest with regard to lateral loads caused by the tractor, is the fact that they did not extend down to appreciable depths. It will be noted from Fig. 8 that the concentrated load began to drop off on each plank immediately after the silage level rose above that particular plank.

A concentrated load for the packing tractor of 200 lb at the surface of the silage seems justifiable for design purposes. This figure is lower than the one indicated by the report(1) on the first two years' tests. The load of 200 lb, however, is one that more nearly always can be anticipated when the tractor goes near the wall. Higher stresses, and particularly those occurring when the tractor wheel rubs against the wall, must be taken care of by the safety factors in design.

Conclusions

1 Maximum unit lateral pressures of 125 to 150 lb per sq ft will occur temporarily at a depth of from 1 to 2 ft below the silage surface during the filling operation.

2 At depths below the 2-ft level of silage the unit lateral pressures relax to approximately 100 lb per sq ft.

3 A single-unit pressure curve for the total depth of silage changes constantly during the silo-filling operation but soon after the silo is filled becomes practically a vertical pressure curve of about 100 lb per sq ft from the 2-ft depth (from the top) down to the 6-ft depth.

4 The overturning moment caused by the lateral stresses in wheat silage harvested with a flail-type chopper is expressed by the equation $Y=33.40X^{2.202}$. These moments are slightly lower at shallow depths and somewhat higher at greater depths than the moments found previously for other kinds of grass silage.

5 The average concentrated lateral loads caused by the packing tractor ranged from 135 to 190 lb at the silage surface. The horizontal load on the silo wall 2 ft below the surface is not affected appreciably by the tractor.

6 A lateral concentrated load of 200 lb at the surface caused by the packing tractor, is justifiable for design purposes.

7 A technique is presented for the construction of aboveground silos that require a comparatively small amount of labor and a minimum of skilled labor and special equipment not available on the farm.

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Land Reclamation Progress in Iraq

W. L. Powers
Member ASAE

Information for this article was obtained during three years while the author was on leave from Oregon State College making irrigability-land classification and use-capability studies with Knappen engineers for the Iraq Development Board. A comprehensive report on the development of the Tigris-Euphrates river systems has been released.

IRAQ has perhaps greater prospects for agricultural expansion than any other country of the Middle East. The total irrigable land in the country along the Tigris-Euphrates drainage system is more than 12 million acres, of which 7 million acres are now under partial irrigation. A major purpose of the Iraq Development Board, created in 1950 to direct the economic development of the country, is to bring the remainder under cultivation. Realization that the nation's oil resources are expendable, whereas land and water, if properly used will serve indefinitely, legislation was set up whereby oil revenues are used to provide works "for increasing the national income and raising the standard of living of the people of the country." Seventy percent of the oil revenues are available to the Board to finance reclamation and other public improvement programs.

Climate

The climate is similar to that of Yuma, Arizona. Mean annual rainfall on the great alluvial plain ranges from 4 in in the south to 10 in in the north. The terrace lands of Kirkuk-Mosul area get 15 in or more. Most of this rain falls in winter. The long, almost year-round growing season permits double cropping. A few degrees below freezing may occur yet dates and citrus succeed throughout most of the alluvial area.

The mean monthly flow of the Euphrates is nearly 30,000 sec-ft and that of the Tigris over 43,000. The combined flood flow may exceed 400,000 sec-ft. So the discharge from the Euphrates is similar to that of the Willamette River of Oregon; that of the Tigris is nearly twice as much, and the combined flood flow is approximately one-half that of the Columbia when in flood.

The great alluvial plain of the twin rivers is nearly flat. The land surface slopes slightly away from the river banks. The few landmarks to be seen are silt ridges along old canal lines, abandoned river beds, mounds, or tells, at ancient population centers. Deposition of alluvium in early times is estimated to have extended into the Persian Gulf one mile in 30 years, and more recently at perhaps one-half that rate. The terrace toward the northeast is conglomerate of sandstone or limestone with residual soil of red chestnut and Mediterranean red earth.

The soils developed under the influence of a subtropical, continental climate and sparse vegetation. In the southwest the trend is toward the type known as gray desert soils. These alluvial soils are usually heavy in texture and similar to Gila silty clay in southwestern United States.

An irrigability land-classification reconnaissance was made of 6 million acres available for future development. Class 1, totaled 6 percent; Class 2, 68 percent; Class 3, 23 percent, and Class 5, 3 percent. Eighty soil profiles studied show generally total nitrogen and organic matter low; and available phosphate low especially in the red soils or those low in humus. Available potash is ample and calcium carbonate abundant.

Salinity control will be necessary for much of the area. Areas with infiltration rates of only ⅛ in per hr and salt concentration as much as three percent were eliminated.

Land-use capability is great, given flood control, perennial irrigation on dry land, and drainage and improved practices in areas now irrigated. The Development Board is concentrating on perennial irrigation of the better areas of publicly owned dry land. The new projects are being settled by family-sized farm units drawn from the great bulk of the population that now owns no land. Membership in an agricultural cooperative is encouraged to meet the need for implements, seed, and agricultural guidance; participation in maintenance is required. Small agricultural industries are encouraged. Elementary education and public-health programs are provided. Ten years' performance is required for title.

The program of irrigation and drainage is designed to utilize fully the waters of the lower Tigris and Euphrates Rivers for irrigation, flood control, power and navigation. Completion of the projects projected will end the threat of floods; give adequate flow through the year for navigation, and provide 1,250,000 kw of hydroelectric power at reservoir sites as a by-product.

The major diversion on the Tigris is from a barrage at Kut, while the Hindiyah barrage diverts water from the Euphrates near Hillah and ancient Babylon.

Current work on the Habbaniyah project consists of raising the barriers to give more storage and flood protection on the lower Euphrates area. The Ramadi barrage, a key structure of the project was completed late in 1955.

The Wadi Tharthar escape to provide flood protection for Baghdad and the lower Tigris area will be finished in 1956 and is one of the largest canals in the world. The Dokan Dam is under construction for storage of water of the lesser Zab, for flood control, irrigation and power. Contract documents have been prepared for the Bekhme Dam on the Greater Zab River. Designs are being prepared for the enlargement of the Hillah Canal and for irrigation and drainage of new lands in the Hillah and Gharraf extensions.

Among the reasons for the decline in production in Babylonia were the choking of channels by silt and dust, salinization, disease, flood and drought, stream migration,

(Continued on page 341)

Information for this article was obtained during three years while the author was on leave from Oregon State College making irrigability-land classification and use-capability studies with Knappen engineers for the Iraq Development Board. A comprehensive report on the development of the Tigris-Euphrates river systems has been released.

The author—W. L. Powers—served as land consultant with Knappen-Tippetts-Abbett-McCarthy Engineers and is emeritus soil scientist, Oregon Agricultural College and Experiment Station.

A Method of Forecasting Soil Loss

C. A. Van Doren and L. J. Bartelli

Annual soil loss for almost any possible combination of conditions can be estimated quickly and with a high degree of accuracy from recently compiled tables and guides. Each of the known factors relative to erosion or soil loss has been assigned an erosion-influence value to fit into a direct-relation formula for fast calculation. Composite tables serve as guides for developing soil and water conservation programs

SEVERAL factors, operating in combination with each other, should be considered in determining the effectiveness of measures for conserving agricultural land. Cooperative research work has been helpful in evaluating some of these factors. By careful study of existing research data it has been possible to formulate tables which indicate expected soil losses. In preparing these tables, consideration has been given to the effect of steepness of slope, length of slope, conservation practices, rotations, and soil types on movement of soil by water erosion. This paper is a report on the research basis for values assigned to the various factors, their relative importance, and their application.

Factors affecting erosion have been studied in Illinois. At the Dixon Springs experiment station, data were collected for 16 years on the effect on soil losses of such factors as steepness of slope, length of slope, and various crops in rotation. At Urbana, measurements were made for 13 years on the effectiveness of contour farming during corn, oats (sweet clover), and soybean production. By making certain adjustments in the data, the effectiveness of various other rotations and practices are calculated. Most of these adjustments are based upon factors developed after consideration of all applicable data. A national work group met in 1946 to study the influence of slope, cropping systems, rainfall, etc., on soil loss. The findings of this group have been helpful in assigning values to the factors reported herein.

Tables were prepared for estimating soil losses for use in Illinois early in 1947. They were improved and simplified by tables prepared in January 1948. The most intensive cropping systems suitable for different soils, slopes, and erosion-control practices were prepared from the 1948 tables and made available for field use in Illinois in 1950. These slope and practice limitations were included in a handbook containing general suggestions for the management of soils, crops, and pastures under Illinois conditions.*

Slope Factors

Soil losses from erosion plots increase exponentially as the steepness of slope and length of slope increase. Zingg (14)† found soil loss to be proportional to the 1.49 power of the land slope in percent and soil loss in tons per acre to be proportional to the 0.53 power of the horizontal length of the slope. Musgrave (6) reported relationships of $S^{1.35}$ for steepness of slope and $L^{0.37}$ for horizontal length. Browning *et al.* (2) and others have used similar factors in estimating soil losses from agricultural land.

The relationship of soil loss to steepness and length of slope was determined for the plots at the Dixon Springs experiment station. Soil and water losses were measured from plots located on 5 and 9-percent slopes with lengths of 36, 70, 140, and 210 ft. All plots were 35 ft wide and were farmed to a rotation of corn, winter wheat (lespedeza), and lespedeza. The soil type is Grantsburg silt loam, a moderately well-drained gray-brown podsolic, fragipan soil developed from moderately deep loess (SCS code 3M31DG). The plots were described in greater detail by Gard and Van Doren (3).

Steepness of Slope. The values from Dixon Springs on 5 and 9-percent slopes were plotted on logrithmic paper and the ratio of Y (annual soil loss in tons per acre) to X (slope steepness in percent) was determined (Table 1, Fig. 1). The regression coefficient or exponent for steepness of slope as plotted ranged from 1.45 to 1.53. The average exponent for steepness of slope was 1.5 (symbolized by $S^{1.5}$). The adjusted annual soil loss at Urbana on 2-percent slope from plots 180 ft in length was 3.5 tons per acre from continuous cropping for a period of 13 years (1941-1953)‡. The soil is Flanagan silt loam, an imperfectly drained Brunizem developed from 40 in of loess on

‡During four years, 1941-1944, losses from continuous corn were calculated from losses secured from plots in corn, oats (sweet clover catch), two-year rotation.

TABLE 1. SOIL LOSSES FROM 5 AND 9-PERCENT SLOPES DURING CORN PRODUCTION ON VARIOUS LENGTHS OF PLOTS ON GRANTSBURG SILT LOAM*

Plot length, feet	Crop	Dixon Springs Experiment Station (1939-1946) Average soil loss per year, tons per acre 5% slope	9% slope	Estimated relationship
35	Corn	4.0	9.8	$S^{1.53}$
70	"	5.6	13.6	$S^{1.50}$
140	"	6.6	15.7	$S^{1.52}$
	Average per storm, tons per acre			
Selected storms†	"	1.35	3.14	$S^{1.45}$

*Losses from plots in corn (in a 3-year rotation) were considered more representative of losses from the two slopes than the losses from all crops in the rotation. The 5-percent slopes of Grantsburg silt loam in the area have a lower base exchange capacity than the 9-percent slopes which resulted in poorer stands and less vigor in winter wheat on 5-percent than on 9-percent slopes.

†Average loss per storm from all lengths from six intense storms with intensities exceeding 0.94 in during a 30-min period.

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The authors — C. A. VAN DOREN and L. J. BARTELLI — are, respectively, soil conservationist (SWCRB, ARS), U.S. Department of Agriculture, and soil scientist (SCS), U.S. Department of Agriculture.

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*A guide for the management of soils, field crops, and pastures in Illinois, Illinois Agricultural Experiment Station and Soil Conservation Service (1950).

†Numbers in parentheses refer to the appended references.

loam-textured, Wisconsin aged till (SCS code 2M44DG). All estimated losses calculated by using the method presented in this paper are based upon losses from Flanagan silt loam as projected to other slopes and practices. Using the relationship of $S^{1.5}$, basic soil losses on Flanagan silt loam were projected from a 2 to an 18-percent slope as shown in Fig. 2.

TABLE 2. SOIL LOSSES FROM VARIOUS LENGTH OF PLOTS DURING A ROTATIONAL SEQUENCE ON GRANTSBURG SILT LOAM ON 5 AND 9-PERCENT SLOPES*

Dixon Springs Experiment Station (1939-1946)				
Steepness of slope, percent	Annual soil loss by length of plots, tons per acre			Relationship
	35 ft	70 ft	140 ft	
5	4.8	7.0	8.6	$L^{0.42}$
9	7.5	10.0	12.1	$L^{0.34}$

*Average yearly losses from contoured plots (not ridged) in rotation of corn, winter wheat (lespedeza), and lespedeza. The plots which were 210 ft in length were omitted from the computations since these plots had a concave-shaped slope which favored deposition of soil on the lower portions of the plot above the collecting troughs.

Length of Slope. A relationship for length of slope was calculated from plots ranging in length from 35 to 140 ft on Grantsburg silt loam (Table 2). Lines were fitted to the data as shown in Fig. 3 by using the standard exponential equation:

$$\text{Log } Y = a + b \log X.$$

where Y = soil losses in tons per acre
a = point where line crosses Y axis
b = regression coefficient or exponent for length
X = length of slope.

The relationship for length on the 5-percent slopes was $L^{0.4211}$ and on the 9-percent slopes $L^{0.3449}$. The average of these two values is $L^{0.38}$, which was used in estimating soil losses from the Flanagan silt loam at Urbana. The values from the line in Fig. 2 were placed on logarithmic paper at $Y = 180$ ft in Fig. 4 and a line run through the various basic values to project from 50 to 200 ft in length. The relationship $L^{0.38}$ was not used in projecting beyond 200 ft since field experiences indicate that concentrated flow of water on long slopes may present hazards not reflected in erosional losses. Beyond 200 ft the relationship was increased arbitrarily from $L^{0.38}$ to $L^{0.60}$. This provides a safety factor on long slopes.

TABLE 3. ESTIMATED EFFECTIVENESS OF ROTATIONS AND CROPS IN ROTATIONS IN CONTROLLING EROSION EXPRESSED IN PERCENT OF LOSSES FROM CONTINUOUS CORN*

Rotation†	Crop C1	C2	C3	C1	GR1	GR2	GR3	M	Ave.	Factor used‡
Corn§	100								100	1.00
2-1ˣ-0‖	70	90			25			0	62	0.61
4-1-1	50	90	95	100	25			2	60	0.61
1-1-0	85				25			0	55	0.55
3-1-1	45	85	95		25			2	50	0.50
1-1ˣ-0	60				22			0	41	0.40
2-1-1	45	85			25			2	39	0.40
2-2-1	45	85			25	25		2	36	0.36
1-3ˣ-0	50				30	25	25	0	32	0.32
2-1-2	35	65			22			2	25	0.25
1-3-1	45				25	25	25	2	24	0.25
1-1-1	45				21			2	23	0.23
1-2-1	45				20	25		2	23	0.23
2-1-3	35	65			22			2	21	0.21
1-1-2	35				17			2	14	0.14
0-2-1					15	20		2	12	0.12
1-1-3	30				15			2	10	0.10
2-0-1¶										0.10
1-1-4	30				15			2	9	0.09
0-1-4					15			2	5	0.05

*Based on unpublished plot data assembled by national group of research workers (1946).

†C=row crop; GR=small grain; M=meadow. The number which follows the letters indicates the successive number of years the crop occurs in the sequence.

‡For poor management, these factors may be multiplied by 1.3; for high-level management, the factors may be multiplied by 0.7. For skip-row or wide-row planting with the soil surface protected by living or dead mulch in the wide spacings, factors may be multiplied by 0.5.

§Continuous row crop, corn or soybeans.

‖The first number indicates the number of years of row crop; the second number, small grain; the third number, meadow. The symbol x by the small grain indicates a green manure crop.

¶Skip-row (40 in - 40 in - 80 in planting) or wide-row (60 in or more) with corn planted on contour and with wide spacing protected by a living or dead mulch.

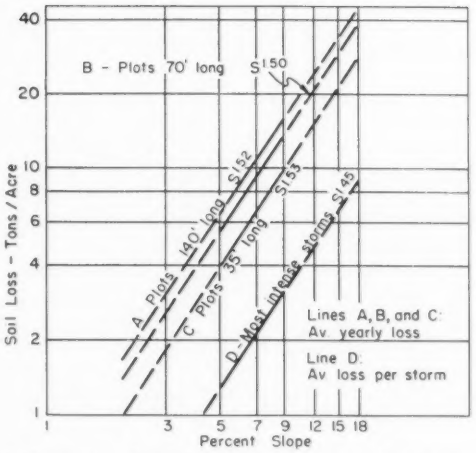
B - Plots 70' long S^1.50
A - Plots 140' long S^1.52
C - Plots 35' long S^1.53
D - Most intense storms S^1.45
Lines A, B, and C: Av yearly loss
Line D: Av loss per storm
Soil Loss - Tons / Acre
Percent Slope

Fig. 1 Regression of soil losses during corn production on steepness of slope (Table 1)

Crop and Rotation Factors

The relative effectiveness of various rotations for controlling erosion was expressed as a percentage of the expected soil losses while growing continuous corn. The values used in this paper were developed from information furnished by the group of research workers who analyzed the data from various soil erosion experiment stations located in the humid section of the United States in 1946. The rotation factors shown in the last column of Table 3 were used in Table 10 in combination with soil factors. By using the individual crop values the relative effectiveness of other

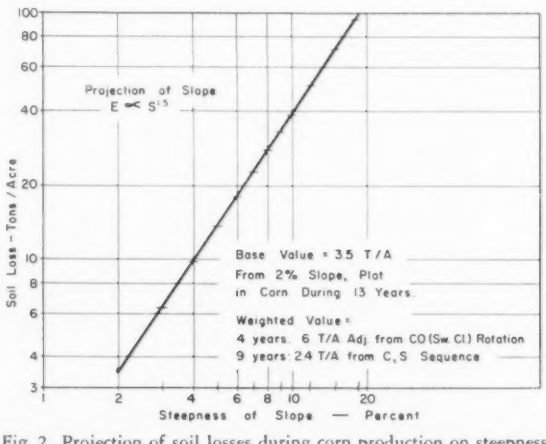
Projection of Slope
E ∝ S^1.5
Base Value = 3.5 T/A
From 2% Slope, Plot
in Corn During 13 Years.
Weighted Value =
4 years: 6 T/A Adj. from CO (Sw. Cl.) Rotation
9 years: 2.4 T/A from C, S Sequence
Soil Loss - Tons / Acre
Steepness of Slope — Percent

Fig. 2 Projection of soil losses during corn production on steepness of slope. Flanagan silt loam with plots 180 ft in length

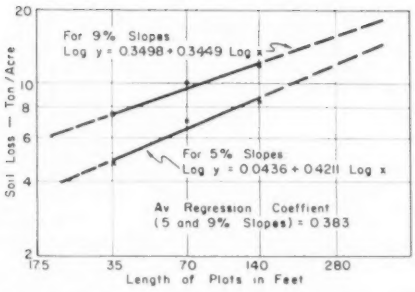

Fig. 3 Regression of soil losses from 5 to 9-percent slopes during corn production on length of slope (Table 2)

rotations may be calculated. The rotation factors reported in Tables 3 and 10 are considered correct when good soil and crop-management practices are followed.

Management is defined as good when the soil is treated to correct soil deficiencies according to soil tests and occasional application of manure or occasional plowing under of clover or meadow crops. Poor management constitutes removal or close grazing of most residues, inadequate soil fertilization, and tillage operations in excess of those required to control weeds or to provide conditions for optimum germination of crop seeds.

High-level management is defined as the use of mulch-tillage practices for row-crop production, or the plowing under of all crop residue and the last legume crop in the rotation. In addition, with high-level management, it is also necessary that the soil be fertilized to compensate for crop removals and the row crops should be produced with a minimum of tillage. A plow-plant or skip-row system for production of row crops would qualify for high-level management provided other conditions of soil treatment and use of residues were satisfied§.

§A plow-plant system of corn production involves plowing immediately preceding planting without disking. A skip-row method is one providing for wide-row planting or skipping of approximately one row in three. A living or dead mulch should be provided in the wide spacings between the rows.

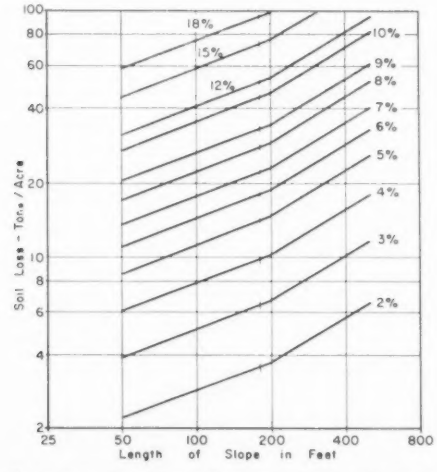

Fig. 4 Projection of soil losses from 2 to 18-percent slopes during corn production on length of slope. Relationship for length is $L^{0.38}$ from 50 to 200 ft and $L^{0.60}$ from 200 to 500 ft

Musgrave (5) outlined some of the interacting forces and resistances involved in protecting the soil from erosion. He called attention to the necessity of carefully examining each local soil conservation problem. Treatments must be designed to meet the dominant needs for protection against the hazards involved at various seasons of the year. Van Doren *et al.* (13) reported that 64 percent of the total annual soil losses from corn on Flanagan silt loam at Urbana occurred during the month of June. A number of vegetal, climatic, and soil conditions contributed to excessive losses from one rain during wheat production, as reported by Gard and Van Doren (3). Gard *et al.* (15) have reported that soil losses can be reduced one-third on winter wheat following corn by disking the cornstalks in preparing the seedbed instead of removing the stalks for silage. Van Doren and Stauffer (12) found soil losses, in pounds per acre, ranged from 14 to 149 times greater from unmulched than from plots protected with a straw mulch.

As an approximation, since good management was considered unity, poor management has been assigned a factor of 1.3 and high-level management a factor of 0.7. The rotation factors shown in Table 3 should be multipled by these values where poor or high-level management is definitely being followed.

Conservation Practices

The effectiveness of supporting conservation practices in reducing erosion have been reported by many (1, 2, 4, 7, 10, 11). The value of supporting conservation practices will vary depending upon steepness and length of slopes. Their effectiveness will also be modified by different crops. For a practice to be successful, soil losses should be reduced materially during the production of row crops.

Effect of Contouring. At Urbana, on Flanagan silt loam with a 2-percent slope, crops were grown on plots up and down the slope and on the contour. For the 13-year period the soil losses on a 2-percent slope from contoured plots were only 0.52 as much as from plots planted up and down the slope (Table 4). Recognizing that field contouring may be less effective than contouring on research plots, a factor of 0.6 was used on 2-percent slopes in preparing the tables. Contouring is most effective on slopes around 5 to 8 percent. As flat slopes are approached, the difference in grade between rows contoured and non-contoured becomes less, which accounts for the factor being greater on 2-percent slopes than on 5-percent slopes. On both nearly level lands and on steep slopes, soil losses are probably equal from contoured and non-contoured plots.

TABLE 4. EFFECT OF CONTOUR FARMING ON SOIL LOSSES
Urbana, Ill. Flanagan silt loam, slight erosion, 2-percent slope, plots 180 x 53.5 ft.

Rotation	Crop	Up and down Planting tons per acre	Contour* tons per acre	Efficiency factor
Corn, oats (sweet clover catch) (1941-44)	corn	4.0	2.5	0.62
	oats	0.8	0.5	0.62
Average		2.4	1.5	0.62
Corn, soybeans (continuous row crop) (1945-53)	corn	2.7	1.1	0.41
	soybeans	2.1	0.5	0.24
Corn (13-year average) (1941-53)	corn	3.1	1.6	0.52

*Contoured with rows ridged during cultivation.

TABLE 5. EFFICIENCY FACTORS FOR CONTOURING FOR VARIOUS SLOPES EXPRESSED AS RATIO OF LOSSES FROM UP-AND-DOWN TILLAGE

Slope percent	Factor
0	1.0
2	0.6
3-8	0.5
9	0.55
10-11	0.6
12	0.65
15	0.8
18	0.9
25	1.0

The estimated soil losses under contouring as shown in Table 11 were secured by multiplying the value in Table 5 by the estimated basic soil losses from Flanagan silt loam.

Strip Cropping. Hays *et al.* (4), Borst *et al.* (1), and Smith *et al.* (10) found that soil losses from strip-cropped plots were about 0.5 of the losses from contoured plots. The estimated basic soil losses from contoured corn on Flanagan silt loam were multiplied by the factor 0.5 to secure an estimated value for strip cropping in Table 11.

Terracing. Soil losses from terraced areas have been reported by Smith *et al.* (10), Hays *et al.* (4), Borst *et al.* (1), and Musgrave and Norton (7). A large percentage of soil moving between terraces is collected in the channel. Smith (16) stated that 90 percent of the soil moved was retained in the terrace channel. Since soil deposited in terrace channels may be moved back on the field, terraces may be credited with soil savings in excess of those due to decreased slope length.

For use in this paper, the estimated soil losses were calculated from a slope length equaling the horizontal terrace spacing when contoured and this soil loss value was multiplied by the factors shown in Table 6.

Soil Factors

There is evidence to show that various soils erode at different rates, depending upon the inherent physical characteristics and amount of past erosion. In order to apply the collected soil-loss data to different soils within the state, it was necessary to estimate relative soil-erodibility rates and calculate the influence of past erosion.

Soil Erodibility Factor. Relative soil-loss rates were calculated for the soils at Dixon Springs, Ill., and LaCrosse, Wis., by comparison with Flanagan silt loam which was assigned a rating of 1.0. Since the Flanagan silt loam at Urbana was used as the standard, soil losses at the other sites were adjusted to the same length and percent of slope,

TABLE 6. ESTIMATED EFFECTIVENESS OF TERRACING ON DIFFERENT SLOPES

Soil Losses* Based on Flanagan Silt Loam at Urbana, Ill.

Slope percent	Length of slope, ft (equivalent to terrace spacing) feet	Soil loss estimated (contoured), tons per acre	Terracing factor	Soil loss estimated (terraced), tons per acre
2	120	1.8	0.5	0.9
3	100	2.6	0.5	1.3
4	90	3.7	0.5	1.9
5	82	5.1	0.5	2.6
6	75	6.3	0.6	3.8
7	70	7.7	0.6	4.6
8	66	9.5	0.6	5.7
9	63	12.1	0.6	7.3
10	60	17.4	0.65	11.3
12	54	20.8	0.65	13.5

*From continuous corn.

TABLE 7. RELATIVE SOIL LOSSES FROM SOILS ON SELECTED EXPERIMENT STATIONS

Soil	Location	Soil factor, *K*
Flanagan silt loam	Urbana, Ill.	1.0
Grantsburg silt loam	Dixon Springs, Ill.	1.5
Fayette silt loam	LaCrosse, Wis.	1.3

conservation practice, cropping sequence, and rainfall intensity. Flanagan silt loam under continuous row crop on a 2-percent slope, 180 ft long, farmed up and down the slope, lost 3.5 tons per acre per year. Table 7 gives the relative soil loss of Grantsburg and Fayette soils compared with Flanagan and adjusted for rainfall characteristics of the locations. It was assumed that these differences were due to characteristics inherent in the soil.

Using the calculated soil factors from these soils as guides and considering the characteristics of the soils in the state in relation to those at the experiment stations, soil-erodibility factors as shown in Table 8 were developed. Adjustments for rainfall differences were made where necessary in assigning an erodibility factor. The state was divided into zones in accordance with reported 30-min rainfall intensities and adjustments considered on the basis of the relationship reported by Musgrave (6) of $P_{30}^{1.75}$.

Influence of Previous Erosion. The influence of previous erosion on soil losses has been measured at various soil conservation experiment stations (1, 4, 7, 10). Reports indicate that on some soils the current rate of soil loss tends to increase with an increase in the amount of previous erosion. On other soils the current rate of soil loss may decrease as erosion progresses. As erosion progresses, yields usually decrease and other unfavorable conditions of tilth and moisture availability may develop. Factors were arbitrarily assigned for different degrees of previous erosion to provide for an increase in erodibility and for less desirable physical conditions as erosion progresses. Since soil losses were based on measured losses at the Urbana station and the past erosion at this site was classed slight erosion (1=more than 8 in of A horizon remaining), a deterioration factor of 1.0 for slight to no apparent erosion was used. A factor of 1.2 was used for moderate erosion (2=3 to 8 in of A horizon remaining, usually a mixture of surface and subsoil). Soil loss from a moderately eroded soil would be 1.2 times that of the Urbana plots providing all other conditions affecting erosion are equal. A factor of 1.4 was used for severe erosion (3=less than 3 in of *A* horizon remaining, largely subsoil).

TABLE 8. ERODIBILITY FACTORS FOR ILLINOIS SOILS*

Soil area	Factor, *K*
Muscatine silt loam, Saybrook silt loam, Flanagan silt loam, etc., SCS groups 9, 75	1.0
Elliott silt loam, etc., SCS group 29	1.1
Swygert silt loam, etc., SCS group 72; Miami silt loam etc., SCS group 24; Fayette silt loam, etc., SCS group 10; Harrison silt loam, etc., SCS group 77; Warsaw silt loam, Onarga sandy loam, etc., SCS group 40	1.2
Alvin sandy loam, Ellison silt loam, SCS group 42; Herrick silt loam, etc., SCS group 13; Clarence silt loam, etc., SCS group 32	1.3
Blount silt loam, Eylar silt loam, etc., SCS groups 31, 33	1.4
Cisne silt loam, Hoyleton silt loam, etc., SCS groups 34, 35, Grantsburg silt loam, Hosmer silt loam, etc., SCS groups 15b, 15a	1.5

*Refer to Table 9 for major characteristics of soil groups.

Soil-Loss Factor

Soil-loss factors have been assigned to the various soils in the state. In assigning these rates many factors such as rate of weathering of soil material, soil-building potential of the material below the surface soil, texture of the subsoil, nutrient content of the subsoil, climate, and a host of others should be considered. There is little research data available on which to base the evaluation of these factors. Since the ultimate objective of the soil conservation program is to increase and maintain crop production, soil-loss factors were related to crop yields. The soil-loss factors were based on the crop-yield data on soils of varying surface depth, indicating the relationship of erosion to crop production under somewhat similar fertility programs.

Table 9 lists the reduction in corn yield per inch of topsoil lost from selected soils as reported by research workers, and the related soil-loss factors. The Tama soil was used as a base and the assumption was made that a soil loss of 4.5 tons per acre per year, which would require approximately 35 years to erode an inch of soil, would not materially affect the crop production on this soil. One inch of soil lost over a 35-year period should be compensated for by the additions of fertilizers, use of crop rotations, soil-building ability of subsoil, and tillage practices, so that soil fertility and crop production would be maintained. In assuming this soil-loss rate, it was assumed that there were no damaging effects such as gullying, detrimental sedimentation and excessive removal of plant food. The ratio was calculated for the reduction in yield per inch of topsoil lost from Tama compared with reduction in yield from other soils. This ratio was applied to the 4.5 tons per acre soil loss to secure a soil-loss factor for the other soils. Using the rates on Table 9 as a base, and, after considering the characteristics of other soils, soil-loss rates were assigned to the remainder of the soils included in Table 10.

Method of Combining Factors

The discussion to this point has been largely a presentation of the relationship of independent variables to soil loss. The combined effect may be expressed by an erosion equation; then portions of the equation are combined into tables for field use.

Erosion Equation. Soil losses may be estimated by using the following erosion equation:

$$A = f\,(T, S, L, P, K, I, E, R, M) \quad . \quad . \quad . \quad . \quad . \quad [1]$$

where: A = annual estimated soil loss in tons per acre

T = tons per acre of measured soil loss from soil type

TABLE 9. REDUCTION IN CORN YIELD PER INCH *A* HORIZON LOST AND RELATED SOIL-LOSS FACTORS

Base: A soil loss rate of 4.5 tons per acre per year on Tama

Soils, used as reference*	Reduction in corn yield (bushels per acre) per in *A* horizon lost¶	Soil-loss factors, tons per acre per year	Major soil Series in Illinois	Major characteristics of soils
Tama silt loam†	1.1	4.5	Muscatine, Tama, Saybrook, Flanagan, Bolivia, Sidell, Tonica (SCS groups 9, 75, 22, 29d)	Dark colored prairie (Brunizem) soils, deep, moderately well to well-drained, moderate permeability, silt loam surface, silty clay loam subsoil (*B* horizon) medium base status in *B* horizon
Fayette silt loam‡	1.5	3.5	Fayette, Clary, Camden, Alma (SCS groups 10, 15a)	Light colored timber (Gray-Brown Podzolic) soils, deep, moderately well to well drained, moderate permeability, silt loam surface, silty clay loam subsoil (*B* horizon) medium base status in *B* horizon
Mexico silt loam§	3.5	1.4	Clarence, Oconee, Cisne, Cowden, Bluford (SCS groups 16, 17, 18, 19, 20, 21, 32, 34, 35, 36)	Light to dark colored (Planosols and Brunizem) soils, silt loam surface with tight silty clay to clay subsoils, medium to very low base status in *B* horizon. Imperfectly to poorly drained, very slow permeability
Swygert silt loam†	3.0	1.7	Swygert, Eylar, (SCS groups 33, 72, 13a, 14a)	Dark colored prairie (Brunizem) soils, silt loam surface with silty clay subsoil, slow permeability, imperfectly drained, medium base status in *B* horizon
Grundy silt loam‡	2.7	1.9	Herrick (SCS group 13)	Moderately dark to dark prairie soil (Planosol-Integrade to Brunizem) silt loam surface with heavy silty clay loam subsoils, moderately slow permeability, imperfectly drained, low-base status in *B* horizon
Seaton silt loam	1.2**	4.1	Seaton, Sylvan, Worthen, Mt. Carroll (SCS groups 1, 3)	Light to dark colored (Regosols and Integrades to Brunizems and Gray-Brown Podsolics), deep loess soils with very slight development in *B* horizon medium to high-base status in *B*, texture of *B* heavy silt loam, well to moderately well drained, moderately rapid permeability
Ava silt loam	2.1**	2.5	Ava, Hosmer (SCS group 15b)	Light-colored silt loam (Gray-Brown Podsolic), slow permeability, moderately well drained, with silty clay loam subsoil, very low base status
Miami silt loam	1.7**	3.0	Miami, Pecatonica, Strawn, Blount, Alvin, Ellison, Sabina, (SCS groups 24, 25, 31, 42, 43, 78)	Light colored silt loams (Gray-Brown Podsolic) with silty clay loam subsoil, moderate permeability, moderately well to well drained. Medium-base status in *B* horizon
Elliott silt loam‖	1.3	4.0	Elliott, Douglas, Harrison, (SCS groups 14, 40, 77, 29)	Dark-colored silt loams (Brunizem) with silty clay loam subsoil, moderately slow to moderate permeability. Moderately well to well drained. Medium to slightly below normal base status in *B* horizon
Onarga sandy loam	1.5**	3.5	Onarga, Ridgeville, Rankin, Wesley, (SCS groups 41, 39, 82, 23a, 30, 23)	Dark colored sandy loams (Brunizem) with sandy clay loam to clay loam *B* horizon. Moderate permeability, medium base status in *B* horizon. Imperfect to well drained
Sumner sandy loam	1.3**	4.0	Sumner, Hagner, Discoe, Levan, Potomac, Bloomfield, Unity, (SCS groups 11, 44, 5, 85, 87, 88)	Dark to light colored sandy loams (Brunizem and Gray-Brown Podsolic) with slight subsoil (*B*) development. Moderately rapid to rapid permeability. Imperfect to somewhat excessively drained. Medium base status in *B* horizon
Dubuque silt loam (shallow phase)	3.3**	1.5	Dubuque, Plattville, (shallow) Lorenzo, Derinda, (shallow) (SCS groups 47, 47a, 47b)	Shallow soils, 10-20 in of soil material on loose gravel, bedrock. Range in drainage from imperfect to somewhat excessive
Dubuque silt loam (moderately shallow phase)	2.1**	2.5	Plattville, Dubuque, (mod. shallow phase) (SCS groups 10a, 75a)	Moderately shallow soils, 20-40 in of soil material on limestone or sandstone. Moderately well to well drained

*Footnotes by soil series names refer to literature which reports reductions in corn yield per inch *A* horizon lost for the specific soil. When no footnote is shown, assume rates are included based upon field observations.

†Odell, R. T., Numbers 8 and 9 in the appended references.

‡Aandahl, A. R., Estimation of soil productivity in relation to land values and farm management, Ph.D. thesis, Iowa State College (1949).

§Smith, D., Whitt, D., Annual report soil conservation research, Columbia, Mo. (1948).

‖Rust, R. H., University of Illinois Experiment Station, Agronomy Memo 1472.

¶It should be noted corn yields for such soils as Mexico, Clarence, Swygert, shallow Dubuque would be reduced more than shown in the table if the *B* horizon were exposed.

**Assumed rates.

TABLE 10. COMBINED SOIL, RAINFALL, ROTATION FACTORS*†

Soil factors (KI)	1.0			1.1			1.2					1.3				1.4			1.5		
Soil-loss factors, tons/acre/year‡	4.0	4.5		4.0			1.5	2.5	3.0	3.5	4.0	1.5	2.0	3.0	4.0	1.5	3.0	3.5	1.5	2.5	
SCS soil groups	1 1L	9 75 22 29d		29 31d			47 47a 47b 72	10a 75a	24 25	10	14 40 77 3 3L	32	13	42 43	11	16 13a 33	31 78 72d	15a	17 18 19 20	21 34 35 36	15b
Degree of erosion (E)	3	2	1	3	2	1	3	2	1			3	2	1		3	2	1	3	2	1
Rotation (R)§ Continual corn			1.00			1.10			1.20					1.30				1.40			1.50
2-1[X]-0 and 4-1-1	.85	.73	.61	.94	.80	.67	1.02	.88	.73			1.11	.92	.79		1.20	1.02	.85	1.28	1.10	.92
1-1-0	.77	.66	.55	.85	.73	.60	.92	.79	.66			1.01	.86	.72		1.08	.92	.77	1.16	.99	.82
3-1-1	.79	.66	.50	.77	.66	.55	.84	.72	.60			.91	.78	.65		.98	.84	.70	1.05	.90	.75
1-1[X]-0 and 2-1-1	.56	.48	.40	.62	.53	.44	.67	.58	.48			.73	.62	.52		.78	.67	.56	.84	.72	.60
2-2-1	.50	.43	.36	.55	.48	.40	.60	.52	.43			.66	.56	.47		.71	.60	.50	.76	.65	.54
1-3[X]-0	.45	.38	.32	.49	.42	.35	.54	.46	.38			.59	.50	.42		.63	.54	.45	.67	.58	.48
1-3-1 and 2-1-2	.35	.30	.25	.38	.33	.28	.42	.36	.30			.45	.38	.32		.49	.42	.35	.52	.45	.38
1-1-1 and 1-2-1	.32	.28	.23	.35	.30	.25	.39	.33	.28			.42	.36	.30		.45	.39	.32	.48	.41	.34
2-1-3	.29	.25	.21	.32	.28	.23	.35	.30	.25			.38	.32	.27		.41	.35	.29	.44	.38	.32
1-1-2	.20	.17	.14	.22	.18	.15	.24	.20	.17			.25	.22	.18		.27	.24	.20	.29	.25	.21
0-2-1	.17	.14	.12	.18	.16	.13	.20	.17	.13			.22	.19	.16		.24	.20	.17	.25	.22	.18
2-0-1‖ and 1-1-3	.15	.12	.10	.15	.13	.11	.17	.14	.12			.18	.16	.13		.20	.17	.14	.21	.18	.15
1-1-4	.13	.11	.09	.14	.12	.10	.15	.13	.11			.17	.14	.12		.18	.15	.13	.19	.16	.14
0-1-4	.07	.06	.05	.08	.06	.05	.08	.07	.06			.09	.08	.07		.10	.08	.07	.11	.09	.08

KIER of equation: $A=f\ (TSLP)\ (KIERM)$ explained in text

†Values in table based on good management. For high level management, multiply above factors by 0.7, and for poor management multiply by 1.3

‡Soil-loss factors listed above apply to 1 and 2 erosion. For 3 erosion multiply soil-loss factors by 0.7

§The first number indicates number of years of row crop, the second number indicates years of small grain, the third number indicates meadow. The symbol X by the small grain indicates a green manure crop

‖Skip-row or wide-row plantings

(considered unity) of given slope, with known conservation practices and cropping pattern

S = steepness of slope

L = length of slope

P = practice effectiveness (appropriate factor expressing effectiveness of the particular supporting practice or practices under consideration in solving for A above)

(T, S, L, P are combined in Table 11.)

K = soil erodibility‖

I = intensity and frequency of 30-min rainfall (It was combined with the soil factor K in assigning erodibility factors for the various soil groups within Illinois)

E = previous erosion (expresses effect of influence on current erosion or influence on yields or physical condition of rooting zone)

R = rotation effectiveness

M = management.

(K, I, E, R, M are combined in Table 10.)

Use of Factors in Preparation of Tables. One can check back to other tables, charts, and the text to see how the various factors are considered to operate independently to influence erosion and how they are combined in the tables. For example, Table 3 indicates that a 2-2-1 rotation is only 0.36 as erosive as continuous corn. Assume a soil with a soil-rainfall factor ($K\ I=1.2$), erosion factor ($E=1.0$), and good management ($M=1$); then $(K\ I)\ E\ R\ M=1.2\times 1.0\times 0.36\times 1=0.43$, which is the value shown in Table 10 for soils with a 1.2 factor.

The base value is 3.5 tons per acre from Flanagan silt loam, 2-percent slope, 180 ft in length, up-and-down farming. Projecting these losses from a 2 to a 9-percent slope, we get 33.0 tons per acre for $T\ S$ (Fig. 2). Projecting the 33.0 tons per acre from a slope length of 180 ft to 300 ft, we get 45 tons per acre for $T\ S\ L$ (Fig. 4). In Table 5, the factor for contouring is listed as 0.55. $(T\ S\ L)\ P=45\times 0.55=25$ tons per acre, which is the value shown in Table 11.

The values from Tables 10 and 11 are next combined. From Table 10 $(K\ I\ )\ E\ R\ M=0.43$; from Table 11, $T\ S\ L\ P=25$; hence $A=T\ S\ L\ P\times(K\ I)\ E\ R\ M=25\times 0.43=10.8$ tons per acre per year. The estimated soil losses (A) of 10.8 tons per acre per year can be compared to the soil-loss factor in Table 10.

Use of Soil Loss Estimations

Tables 10 and 11 are being used by conservation workers in Illinois as guides in developing soil and water conservation programs with farmers. From these tables, soil losses from crop rotations on any soil type may be estimated by applying the appropriate factors. Adjustments may also be made for such influences as degree of erosion and management. For example, to estimate the soil loss from a 3-1-1 rotation (corn-corn-corn-oats-meadow) on a 5-percent slope, 300 ft long, no practice, and on a soil with an erodibility factor of 1.2 and slight erosion the combined soil, rainfall, rotation factor of 0.60 (from Table 10) is multiplied by the annual soil loss of 19 tons per acre per year found in Table 11 under no practices on a 5-percent slope,

‖When soil groups are localized in different rainfall intensity zones from the Flanagan silt loam at Urbana, the factors were adjusted to provide for this variable by the exponential relationship times 1.75. The K factor, therefore, may include some adjustment for rainfall.

300 ft long. The result is 11.4. This is the estimated annual loss in tons per acre under a good management system.

Referring to the soil-loss factor for this particular soil (soil group 10=3.5 tons per acre per year from Table 10), the estimated soil loss of 11.4 for the above rotation and practice is more than the soil-loss factor. Thus in this example it is necessary to resort to a less intensive rotation or a more intensive practice or both.

TABLE 11. ANNUAL SOIL LOSS FROM NO PRACTICES, TERRACING, CONTOURING AND STRIP CROPPING *(TSLP)**

Soil loss, tons per acre, from continuous corn (Based on Urbana Flanagan silt loam)

Slope, %	No Practices					Contouring†				Strip Cropping†				Terracing‡		Slope, %
	100+	200+	300+	400+	500+	100+	200+	300+	400+	Strip width, ft	200+	300+	400+	Spacing	Soil loss	
2	3	4	5	6	7	2	2.5	3	3.5	100	1	1.5	2	120	0.9	2
3	5	7	9	10	12	2.5	3	4	5	100	1.5	2	3	100	1.3	3
4	8	10	13	16	18	4	5	6	8	100	2.5	3	4	90	1.9	4
5	11	15	19	23	25	5	7	9	11	90	4	5	6	82	2.6	5
6	14	18	24	29	33	7	9	12	15	90	5	6	7	75	3.4	6
7	18	23	30	35	40	9	12	15	18	80	6	7	9	70	4.6	7
8	22	29	36	45	51	11	14	18	22	80	7	9	11	66	5.7	8
9	27	35	45	53	60	15	19	25	29	70	9	12	14	63	7.2	9
10	35	46	59	71	80	21	28	35	43	70	14	17	21	60	11.0	10
12	41	53	69	82	94	27	34	45	53	60	17	22	26	54	13.5	12
15	58	76	97	115	134	46	61	78	92	50	30	39	46			15
18	75	98	124	150	170	68	88	112	135	50	44	56	67			18

**TSLP* of equation: $A=f(TSLP)(KIERM)$—Explained in text.

†Contouring or strip cropping should not be recommended on those slopes which are shown in the table to the right of the heavy lines. Under "No Practices" on slope lengths to the right of the heavy line, use contouring, strip cropping or terracing.

‡On soils such as Clarence silt loam, Swygert silt loam, shallow Dubuque silt loam, etc. (SCS groups 47, 47a, 47b, 72, 32, 33, 34) terracing is recommended only under very careful management as an erosion control practice.

Summary

A method used for determining soil loss from various soils in Illinois under different management and conservation programs is presented. The procedure is based on the analysis and evaluation of the different factors influencing the amount of soil movement. The relative importance of these factors was determined by a study of soil losses under controlled conditions at the various soil experiment stations. Each factor was considered singly while the others were kept constant.

Equation [1] was used in estimating soil loss and to develop tables which have served as guides for soil conservation workers in the development of soil and water conservation farm plans.

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Land Reclamation Progress in Iraq

(Continued from page 334)

erosion and debris, wars, one-crop farming and earthquakes. Permanent agriculture under irrigation involves combating these factors, the use of deep-rooted perennial legumes with summer irrigation in crop rotations, drainage and salinity control, development of improved pastures with farm livestock enterprises, and the use of mineral fertilizers as required. Maintenance of completed facilities for water control is necessary.

The engineers' report* shows the recommended development program may take 25 years and cost one-half billion dollars. The ratio of benefits to costs is 11.9 assuming optimum use of the land and the adoption of modern intensive methods. Iraq has the soil and water resources, which if properly developed will ensure the country a strong economic position and a good standard of living for all its inhabitants in perpetuity.

*Development of the Tigris-Euphrates Valley, KTAM Engrs, Baghdad, Government of Iraq, Development Board (1954).

Time Study of Parallel Terraces

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Parallel terraces, obtained by smoothing out the curves and eliminating point rows, reduce farming time over conventional terraces and may improve farmer acceptance of contour farming

A STUDY of terrace system improvement was started at the Midwest Claypan Experiment Farm, McCredie, Mo., in 1951. A portion of the study involved reconstruction of three conventionally terraced fields to systems of parallel terraces. It was believed that the successful adaptation of parallel terraces to the Midwest claypan soils would eliminate the two chief objections of farmers to terracing—crooked lines and point rows. Time records of the farming operations have been secured during the years 1954 and 1955, from these fields and also from a similarly farmed field of conventional terraces.

Description of Terraces and Fields

The soil of the fields is Mexico silt loam, typical of 10 million acres of Midwest claypan soils. Slopes are under 6 percent in steepness and 400 to 800 ft in length. The general fertility level without treatment is medium to low.

The type of terraces selected for application was a series of alternate ridge and channel types as required for parallel lines, similar to those suggested by Arnold (1)* in 1941. They were planned first on a contour map with 2-ft contour intervals (2). Cuts and fills were made to a final grade of either 0.40 or 0.50-ft drop per 100 ft of length. Variation in grade from level to one percent, as advanced at that time by Jacobson (3) for the more open soils of western Iowa, were not considered desirable for this claypan soil. The particular fields available for the study limited the terrace length to 900 ft or less. Spacing was increased about 25 percent over recommendations at that time and in most cases adjusted to multiples of four corn rows.

The third or fourth terrace on a slope was selected as the key terrace. Curves were smoothed by a bulldozer so that the new terrace could be followed readily by a corn picker and trailing wagon. Little cutting or filling was required on the key terrace. Lines above and below were staked by use of a device mounted on the front of a tractor. The tractor traveled the line of the key or subsequently staked terrace. This device is shown in Fig. 1. It consists of a steel tape fastened to the front center of the tractor and kept perpendicular to the line of travel by lining the tight tape with a pointer on a wood frame mounted on the front of the tractor.

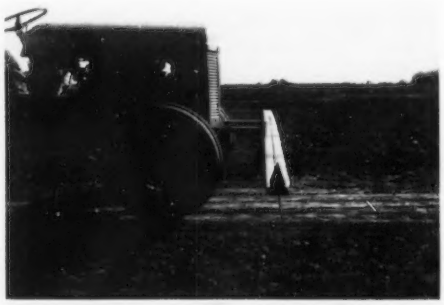


Fig. 1 An attachment consisting of a steel tape for measuring distance to stakes for parallel terrace lines. Tractor travels along the line of the previously staked terrace line

Profile levels were run along the staked lines to determine the amount of cuts and fills and if necessary any needed adjustment of the key terrace line. Cuts on the parallel terraces varied in depths from 0 to 30 in. Excess soil was moved to the adjacent drainage way crossed by the terrace line. On one of the fields it was possible for all five terraces to be parallel with cuts limited to 20 in or less. On the other two fields the land slope flattened toward the outlet side of the field. This required that the lower terrace spacing be widened toward the outlet end to prevent the cut depth from exceeding 30 in. The cut material was used to broaden the fill at the point where the terrace spacing narrowed to provide for easy crossing of the terrace ridge and thus eliminate the need for point rows.

Point-Row Area Reduction

Construction of parallel terraces on these fields reduced materially the area in point rows. Figs. 2 and 3 show the original and also the reconstructed parallel terrace lines for two fields. Point-row areas were reduced from 30 to 7 percent of the total area of the three fields by paralleling of the terraces. Data by fields are shown in Table 1. The table also contains data from three parallel terrace fields (4) on the Midway Farm operated by the agricultural engineering department of the University of Missouri. Point-row areas with conventional terraces on these fields also averaged 30 percent of the total. Paralleling of the terraces reduced the point-row areas to an average of 12 percent. The Midway Farm terraces were longer than those at McCredie, which with a somewhat shallower maximum cut accounts for the smaller reduction in point-row areas. But for the six fields on the two soil areas over 70 percent of the point-row areas were eliminated by paralleling.

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1955, on a program arranged by the Soil and Water Division. Contributed as a cooperative project of the Eastern Soil and Water Management Section (SWC, ARS), U.S. Department of Agriculture and the agricultural engineering department, University of Missouri. Approved as Journal Series Paper No. 1580 of the Missouri Agricultural Experiment Station.

The author—DWIGHT D. SMITH—is agricultural engineer (SWC, ARS), U.S. Department of Agriculture, and research associate, agricultural engineering department, University of Missouri.

*Numbers in parentheses refer to the appended references.

TABLE 1. REDUCTION OF POINT-ROW AREAS ON THREE FIELDS OF MEXICO SILT LOAM SOIL WITH LAND SLOPE OF 1 TO 5 PERCENT AND ON THREE FIELDS OF SEYMOUR SILT LOAM WITH LAND SLOPES OF 3 to 6 PERCENT.

Location and field	Number of terraces	Conventional terraces (Area)			Parallel terraces (Area)		
		Total Acres	Point row Acres	%	Total Acres	Point row Acres	%
McCredie							
2	2	5.37	2.19	41	4.65	.65	14
3	4	7.14	1.75	25	7.84	0	0
4	4	8.01	2.20	27	6.65	.62	9
	10	20.52	6.14	30	19.14	1.27	9
Midway(*)							
A	5	6.70	2.14	32	6.59	.71	11
E	2	5.10	1.44	28	5.10	.64	13
B	2	6.08	1.71	28	6.01	.75	12
	9	17.88	5.29	30	17.70	2.10	12

(*)From M.S. thesis of L. D. Meyer, agricultural engineering department, University of Missouri.

The Production Equation

An equation relating area, row length and width, time for and number of turns, and speed of travel can be written that will cover farming operations on both conventional and parallel terraces, as follows:

$$R=\frac{WNL}{8.25\,NL/S+43{,}560\,t\,(N-1)} \quad . \quad . \quad . \quad [1]$$

where R=production in acres per hour

W=row or cut width of implement in feet

L=average row length in feet

N=total number of rows or cut widths per terrace interval

S=speed in miles per hour

t=time per complete turn in hours.

If the number of turns is considered equal to the number of cut widths instead of one less the equation reduces to

$$R=\frac{SWL}{8.25\,L+43{,}560\,t\,S} \quad . \quad . \quad . \quad . \quad . \quad [2]$$

$$S=\frac{8.25\,RL}{WL-43{,}560\,t\,R} \quad . \quad . \quad . \quad . \quad . \quad [3]$$

$$L=\frac{43{,}560\,A}{N} \quad . \quad . \quad . \quad . \quad . \quad . \quad [4]$$

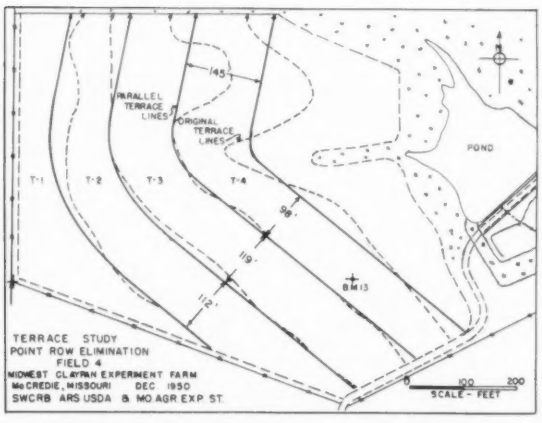


Fig. 2 A 10-acre field of parallel terraces on the Midwest Claypan Experiment Farm, McCredie, Mo., showing the original terrace lines in broken lines. Maximum cut depth on terrace T-4 was 30-in.

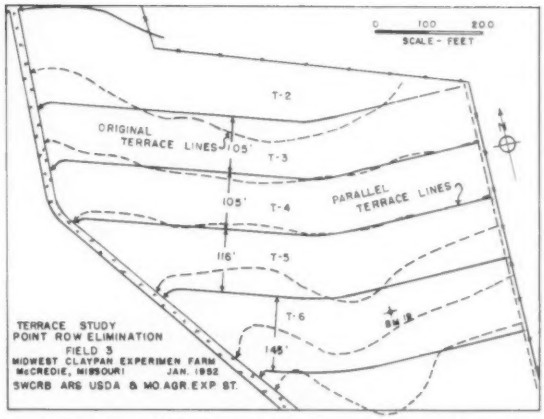


Fig. 3 A 12-acre field of parallel terraces on the same farm. The 20-in maximum cut was on terrace T-2

The area in acres (A) and the number of cut widths per terrace interval (N) can be secured from a scale map of the area. By knowing the total time required for a specific operation over a complete terrace interval and the average time of turning measured with a stop watch, solution of the equation for the average effective speed is possible. For areas on which production rates (R) are not known they can be calculated by assuming a value of S for use in equation [2].

Saving in Production Time

Production time data was secured during 1954 for corn both on a field of parallel terraces and a field of conventional terraces. The data indicated a reduction of 28 percent in operating time for planting, cultivating and shredding stalks. Data on plowing is not reported since plowing of the two fields was at different times and moisture contents. The drought made husking corn unnecessary. During 1955 when all operations were included, the saving in time averaged 17 percent. The data are shown in Tables 2 and 3. Adjusted values for the fields with parallel terraces are used in the comparisons. This was done by use of equations [2] and [3]. It was necessary since the widths of the parallel terrace fields was such that the average row length was less than the average row length would have been if

TABLE 2. PRODUCTION TIME AND PERCENT SAVING BY PARALLEL TERRACES IN PRODUCTION OF CORN DURING 1954

Operation	Production time per acre			Saving in time
	Conventional Measured*	Parallel Measured†	Parallel Adjusted‡	
	Hours	Hours	Hours	Percent
Planting, two 42-in rows	0.56	0.51	0.48	14
Rotary hoe, 2-row	0.34	0.26	0.24	29
Cultivation (1st), 2-row	0.81	0.41	0.38	53
Cultivation (2nd), 2-row	0.42§	—	—	—
Cultivation (3rd), 2-row	0.51	0.48	0.45	12
Shred stalks, 2-row	0.53	0.45	0.42	21
Total hours	2.75§	2.11	1.97	28

*Average row length, 579 ft. If terraces had been parallel, row length would have been 1033 ft. Area consisted of second and third terrace on slope.

†Average row length, 641 ft. Point rows at bottom and top of field.

‡Data from field in second column adjusted to comparable row length (1033 ft) for field in first column.

§Second cultivation time omitted from total.

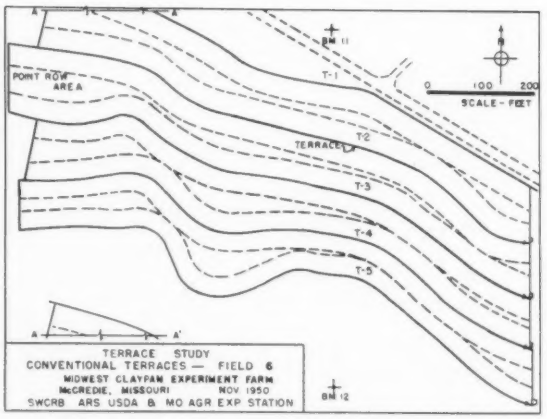


Fig. 4 Point rows between terraces amounted to 20 percent of the total area of this 10.5-acre field of conventional terraces

parallel terraces had been applied to the field with the conventional terraces. Fig. 4 shows the field with the conventional terraces. Row length and other data for the four lower terraces on the field are as follows:

- Average area per interval, 2.25 acres
- Average low length, 555 ft
- Average row length, if parallel, 1048 ft
- Average row length, percent of parallel, 53 percent
- Point-row area, percent of total, 20 percent
- Value of t, 0.008 hr for all fields and operations, except husking, which averaged 0.0061 hr.

The average row length of 555 ft is 25 ft longer than obtained by equation [4]. This difference represents the overlap resulting from planting of the point rows. The tendency to overlap in planting point rows is indicated by stand and harvesting data secured during 1953 and 1954 on the conventional terrace field. Turning within the field to cultivate point rows generally has been considered to result in a reduction of stand and yield at these areas. The data secured did not indicate that there was a significant difference

TABLE 3. PRODUCTION TIME AND PERCENT SAVING BY PARALLEL TERRACES IN PRODUCTION OF CORN, 1955

Operation	Production time per acre Conventional Measured* Hours	Parallel Measured† Hours	Parallel Adjusted‡ Hours	Saving in time Percent
Plowing, two 16-in	1.15	0.92	0.88	23
Disking, 10-ft tandem	0.25	0.24	0.24	4
Disking, 10-ft tandem	0.28	0.24	0.24	14
Planting, two 40-in rows	0.65	0.54	0.53	18
Cultivation (1st) 2-row	0.59	0.51	0.50	17
Cultivation (2nd) 2-row	0.37	0.35	0.34	8
Cultivation (3rd) 2-row	0.41§	—	—	—
Husking, 1 row‖	1.64	1.32	1.28	22
Shred stalks, 2-row	0.40	0.38	0.37	8
Total	5.33§	4.50	4.38	18

*Average row length, 555 ft. If terraces had been parallel row length would have been 1048. Area consisted of second, third, fourth and fifth terraces on slope.

†Average row length, 839 ft. Area consisted of second, third and fourth terraces on slope.

‡Data from field in second column adjusted to comparable row length (1048 ft) for field in first column.

§Third cultivation time omitted from total.

‖Down corn required husking one direction.

TABLE 4. FINAL STAND OF CORN AND CROP YIELD ON STANDARD TERRACE AREAS WHERE POINT-ROW TURNING OCCURRED AND ON ADJACENT AREAS OF SAME TERRACES WHERE THERE WAS NO TURNING

Year	Pairs of samples	Stalks per acre Point-row turning	Stalks per acre No turning	Yield per acre Point-row turning	Yield per acre No turning
1953	2	10,200	8,600	54.5 bu	47.4 bu
1954	6	10,200	10,800	1.06 tons*	1.03 tons*

*Tons dry matter in fodder. Differences are not significant.

in either stand or yield where point-row turning occurred over adjacent areas where there was no turning. Apparently the overlap in planting resulted in a sufficiently greater original stand such that stalks killed by turning did not reduce the stand at harvest or the yield to below that of the adjacent areas. These data are shown in Table 4.

Speed Reduced on Short Rows

The speed or rate of travel was not predetermined for the different operations. The operator's only instructions were to keep a record of starting and stopping time and to exclude any abnormal stoppage such as that caused by mechanical failure of the implement or tractor. In 1954 the same operator covered both conventional and parallel terrace areas. This was not possible during 1955. Also in 1955 the tractor was equipped with a speedometer. The effective speed for each operation during both years was calculated by equation [3]. All values are tabulated in Table 5.

The tendency to reduce tractor speed on short rows has been observed for several years. Turning is most always at low speeds. If the distance of travel is short, the operator frequently does not open the throttle as when he has a long row to plow or cultivate. This was evident during 1954 when the same operator worked on both areas, but with a tractor not equipped with a speedometer. The more narrow ratio for 1955 data may have resulted from the operator attempting to maintain the rated tractor speed regardless of row length in an effort to speed operations.

Calculated Saving in Time—Soybeans

Production time records were secured from a field of parallel terraces planted to soybeans during 1955. These

TABLE 5. AVERAGE SPEED OF OPERATION CALCULATED FROM MEASURED PRODUCTION RATES AND OPERATING SPEED EQUATION [3]

Operation	Calculated speed per hour Corn, 1954 Conventional Miles	Corn, 1954 Parallel Miles	Corn, 1955 Conventional Miles	Corn, 1955 Parallel Miles	Soy beans, 1955 Parallel Miles
Plow, two 16-in	—	—	3.39	4.06	2.54
Disk, 10-ft tandem	—	—	3.45	3.45	3.01
Disk, 10-ft tandem	—	—	2.98	3.45	3.82
Harrow, 2-section	—	—	—	—	5.00
Plant†	2.50	2.70	2.23	2.57	2.53
Rotary Hoe†	4.80	6.30	—	—	—
Cultivation (1st)†	1.65	3.53	2.49	2.75	4.15
Cultivation (2nd)†	3.57	—	4.03	4.25	—
Cultivation (3rd)†	2.83	2.91	4.75	—	—
Husking, 1-row	—	—	3.66	4.39	—
Shred stalks†	2.71	3.16	4.11	3.87	—
Average	2.90	3.72	3.29	3.60	—
Ratio of $\frac{S\ (\text{conventional})}{S\ (\text{parallel})}$		0.75*		0.91	

*Both years together ratio is 0.86. †Two-row equipment.

TABLE 6. PRODUCTION TIME AND PERCENT SAVING BY PARALLEL TERRACES IN PRODUCTION OF SOYBEANS 1955

Operation	Production time per acre Conventional Calculated* Hours	Parallel Measured† Hours	Saving in time Percent
Plowing, two 16-in	1.79	1.23	31
Disking, 10-ft tandem	0.42	0.32	24
Disking, 10-ft tandem	0.35	0.27	23
Harrow, 2-section (10-ft)	0.29	0.22	24
Planting, two 40-in rows	0.72	0.57	21
Cultivate, 2-row	0.49	0.37	24
Total	4.06	2.98	27

*Calculated by use of equation [2] assuming speeds 0.86 of those listed in the last column of Table 5 and a row length 0.53 of that from the field with parallel terraces.

†Average for five terraces with a total area of 9.7 acres and an average row length of 690 ft.

data are shown in Table 6.

The rate for conventional terraces was calculated using equation [2] and assuming speeds for conventional terrace operation as 0.86 of those for the parallel terrace field. Theoretically this ratio should increase to unity as the operating speed decreases to the average speed during turning. The plotting of the ratios for the individual operations against speed suggests this trend. There was not, however, sufficient data for establishing a true trend line so a simple average was used. The length of row was also assumed as 53 percent of the length with parallel terraces, the same as determined for the conventional terrace field in corn.

These data while somewhat of a preliminary nature support the theory that operating time can be reduced materially by paralleling of terraces. With data on cost of layout and construction an estimate could be made of the number of years of operation required to pay for the additional original costs for the parallel terraces.

Summary

Parallel terraces have been applied successfully to fields of Claypan soils with land slopes of 6 percent or less.

Point-row areas for conventional terraces averaged 30 percent of total area.

Paralleling of the terraces reduced the point-row areas by over 70 percent.

Point-row areas resulted in an average row length 53 percent of that possible had parallel terraces been used instead of conventional.

Average rate of travel in farming parallel terraced land was 16 percent greater than on conventionally terraced land.

The saving in farming time by paralleling has averaged about 24 percent for corn and soybeans.

Equations, expressing the relationship of area, row length and width, time for and number of turns, and speed of travel applicable to both conventional and parallel systems are presented.

References

1 Arnold, Earl L. The test of terracing practices. AGRICULTURAL ENGINEERING, vol. 22, pp. 261 (July, 1941).

2 Buie, Eugene C. Terrace system planning to reduce point rows. AGRICULTURAL ENGINEERING, vol. 22, pp. 321-324 (September, 1941).

3 Jacobson, Paul. Are point rows necessary on terraced land? *Journal of Soil and Water Conservation*, vol. 6, pp. 172-174. (October, 1951).

4 Meyers, L. D. An investigation of improved techniques in terrace design, layout, and construction. Thesis for M.S. degree, University of Missouri, (June, 1955).

Engineers in Top-Management Positions

ENGINEERS rapidly are replacing bankers and lawyers in top-management positions in industry, reported Dr. John T. Rettaliata, president of Illinois Institute of Technology, in an address at the annual meeting of the American Society of Safety Engineers recently in Chicago and abstracted in *Mechanical Engineering* for January, 1956.

Basing his observations on a recent survey which showed that 40 percent of the present industrial management is engineer-trained, he said that, as policy problems grow more complex, the engineer is being called upon to assume functions beyond the scope of engineering. He stated also that to meet the trend toward increasing managerial responsibilities for engineers, it is necessary to broaden education to encompass training fields other than the engineer's specialty and to replenish and expand the ranks of the profession. He explained that the young engineer must be made aware of the cost factors in productivity, the labor factor and marketability, and he must be made conscious of consumers, advertisers, suppliers and customers.

He said that many technological colleges and universities are becoming aware of the problem of broadening engineering education and are effecting changes and extensions in the curricula aimed at extending the base of engineering education to increase the graduate's potential usefulness in industry.

He urged engineering societies and industry to promote and provide financial assistance through scholarships to encourage secondary-school students to prolong their education at the higher level in institutions of their choice. He pointed out that only six out of every ten of the top-ranking five percent of high school graduates go to college. He reminded his audience that this loss is tremendous in that it represents America's brightest youth.

Another major responsibility he assigned to the engineering profession is the conservation of the country's resources. "It is hard," he said, "for Americans, long accustomed to ideas of boundless resources, to think of ourselves as a nation whose resources are running out. Yet in ever-sharper measure our attention is being called to the growing problem of shrinking stores of natural material wealth. The time has come when we must be truly scientific about the utilization of our resources."

In summary, he said that engineering is entering an era of achievement that will dwarf prior accomplishments because of the rapidly rising population, the exploitation of new areas of scientific development, and the necessity to advance the country's technology as the foundation of national defense.

Guide for Engineers Entering Military Service

A SUMMARY of information helpful in relating agricultural engineering training and experience to military occupational specialties has been prepared by the ASAE Committee on Engineers' Classification in Civilian and Military Service. Mimeographed copies are available on request to ASAE, St. Joseph, Michigan.

NEWS SECTION

True D. Morse on Grassland Farming Program

THE Honorable True D. Morse, Under Secretary of Agriculture, will be principal speaker at a joint session of the National Joint Committee on Grassland Farming and the Power and Machinery Division of ASAE at Hotel Roanoke, Roanoke, Va., on Wednesday, June 20. The Grassland Farming group is holding a meeting in conjunction with the ASAE 49th Annual Meeting and will hold one joint session with the Power and Machinery Division. A program is arranged also for a morning session, June 20, at the Patrick Henry Hotel in Roanoke. On Thursday, June 21, a bus tour of areas of interest to grassland farming is planned. Complete details of the Grassland Farming Program can be found in the ASAE annual meeting program, page 347.

ASEE Annual Meeting

THE annual meeting of the American Society for Engineering Education will be held at Iowa State College, Ames, Ia., on June 25 to 29. Information regarding the meeting may be obtained by writing W. Leighton Collins, Secretary, ASEE, University of Illinois, Urbana, Ill.

Information regarding the 1956 ASEE-sponsored summer schools is also available. The engineering drawing course is planned for June 20 to 24, and the theme is on evaluation of engineering drawing, descriptive geometry, and graphics for the future. A humanistic-social course will be held June 28 to 30. The theme asks the question how can humanistic-social courses be taught most effectively. The third summer school is on construction education. It will be held June 29 to July 1.

Southern AE Association Elects New Officers

AT THE 8th annual meeting of the Southern Association of Agricultural Engineering and Vocational Agriculture, held at Houston, Texas, March 21, the following new officers were elected: R. S. Wheeler, dean of instruction, college of agriculture, University of Georgia, was elected as president; E. T. Swink, head, agricultural engineering department, Virginia Polytechnic Institute, was elected vice-president; A. W. Snell, head, agricultural engineering department, Clemson Agricultural College, was elected as secretary; and G. W. Wiegers, head teacher trainer, University of Tennessee, was elected as fiscal officer.

ASAE Meetings Calendar

June 1, 2 and 3 — TENNESSEE SECTION, Watts-Bar Resort Village, Spring City.

June 6 — CONNECTICUT VALLEY SECTION, Liz's Cafe, Three Rivers, Mass.

June 17-20—49TH ANNUAL MEETING, Hotel Roanoke, Roanoke, Va.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Features Public Lands Program

THE Soil and Water Division of ASAE has extended its annual meeting program one extra day to include problems of special interest in the development and maintenance of military and other grounds connected with public works projects. The program extension is in response to requests from members of the Society who are in the employ of public works and military organizations, and others who serve as consultants on cooperative projects.

The entire day will be devoted to problem discussions relating to such topics as developing and maintaining airfield runways; jet blast erosion along airfield runways; earth covered structures in humid, semiarid and arid areas; highway erosion; hydraulic design of highway bridges and culverts; maintaining military lands; rehabilitation of public and Indian lands; maintenance planning for Army building areas; managing military woodlands; outleasing Navy lands; and maintenance of Navy grounds. For complete details see the ASAE annual meeting program, page 347.

Details for Annual Meeting Extension Exhibits

A NEW high in extension exhibits is expected at the 1956 ASAE annual meeting at Hotel Roanoke, Roanoke, Va., June 17-20.

Announcement of Extension Committee plans for the exhibit, and a call for exhibit entries went out to a list of extension men in industry and public service in April. However, the list was not completed and others interested in submitting entries are invited to do so. Entry forms are to be mailed to subcommittee chairmen before June 1.

Exhibit classes will include motion pictures, publications (bulletins and periodicals), slides and film strips, demonstration models, new text books, extension methods, and radio television material. The subject matter may be in any of the four technical division fields, farm structures, power and machinery, rural electric and soil and water.

The exhibits are to be displayed in Peacock Hall, adjacent to the Crystal Ballroom on the main floor of Hotel Roanoke, throughout four days of the meeting.

Blue ribbon awards will be made for exhibits judged best in each class. The committee has asked for simple exhibits of daily working material used to put across ideas and information, rather than for loud, flashy, expensive exhibits.

Movies prepared by commercial organizations and those prepared by public service agencies will be judged as separate classes. In addition to the ribbon award for each class a leader is awarded which can be attached to the film to indicate that it is an "ASAE Blue Ribbon Award" film.

Publications entries of both bulletins and periodicals will be divided into industrial and public agency classes, with any one person limited to one bulletin entry and/or one periodical entry. The periodical classification will include news letters and other educational publications issued at intervals.

A special "Method Outline" form has been drawn up for use in the "Extension Method" exhibits. Copies may be obtained from ASAE Headquarters.

Radio and television program material exhibits are also to be entered on special forms which are available from Don Brown, Agricultural Engineering Department, Michigan State University, East Lansing, Mich.

Difficulties in judging new textbooks may prevent the awarding of blue ribbons in that class, but entries are invited as of major interest in the exhibit.

Slides and film strips will also be judged in separate public agency and industrial classifications. In the case of demonstration models the classes are indicated as public agency and industrial or commercial. For the purposes of this exhibit the committee especially invites entry of small, portable models which can be packed and carried in the trunk of an auto.

Model exhibits are to "show developments having engineering implications relating to agriculture. The primary objective should be the education of the viewer." They should be in good taste, and talk concerning them by exhibitors or their representatives in the exhibit area should deal with facts. Promotion literature of a technical or semi-technical nature may be displayed with a model or separately, and may be accompanied by blank forms to make it easy for viewers to write for further information. Selling, order taking, or sales promotion in or near the exhibit space is prohibited, and the committee reserves the right to remove exhibits of any violators. Exhibitors must assume responsibility for providing adequate safety measures in connection with their exhibits, including protection of viewers from moving parts.

Exhibit models to be shipped should be addressed to Hotel Roanoke, Roanoke, Va., marked "ASAE Convention."

Each exhibitor will be responsible for setting up, handling, and removing his exhibit model. Models are to be in place by 2:00 p.m., Sunday, June 17, and removed as soon as possible Wednesday, June 20, after 4:00 p.m. Exhibits may not be fastened to the wall or the floor. Each must be self supporting and set on the floor, a table, or a display stand. Convenience outlets for 110-volt current will be available.

Special information on model displays may be obtained from J. L. Calhoun, agricultural engineering dept., VPI Blacksburg, Va.

Entries in the following other extension exhibit classes should be sent to:

Publications—D. W. Derber, agricultural extension section, U. S. Steel Corp., 2831-525 William Penn Place, Pittsburgh 31, Pa.

Movies—B. P. Hess, Westinghouse Electric Corp., Department 10-L, East Pittsburgh, Pa.

Slide and film strips—E. A. Olson, agricultural engineering dept., University of Nebraska, Lincoln.

Extension methods—R. L. Ricketts, extension agricultural engineer, University of Missouri, Columbia.

Textbooks — J. P. Schaenzer, 116 South 28th St., Arlington 6, Va.

Radio and TV—Don Brown, agricultural engineering dept., Michigan State University, East Lansing.

Demonstration models—S. P. Lyle, Federal Extension Service, USDA, Washington 25, D. C.

Hotel Roanoke, Scene of ASAE 49th Annual Meeting, June 17-20

(Left) Hotel Roanoke, Va., will be the center of activity for the 49th Annual Meeting of the American Society of Agricultural Engineers, June 17 to 20. • *(Right)* Members of ASAE and friends will have an opportunity to visit Monticello, the mountain-top home of Thomas Jefferson, while attending the Annual Meeting. Monticello is located near Charlottesville, Va. It was designed and built in a new style of great beauty and far-reaching effect. Many of Jefferson's furnishings, including his unique inventions for making household life easier, are still contained in the building. The gardens also have been restored.

ASAE Annual Meeting Program

THE program of the 49th Annual Meeting of the American Society of Agricultural Engineers to be held at Hotel Roanoke, Roanoke, Va., June 17 to 20, has been mailed to all members of the Society. Nonmembers may obtain complete information by writing the central office of the Society at St. Joseph, Mich.

The first general session of the meeting will be called to order at 1:30 p.m., Tuesday, June 19, by E. T. Swink, chairman of the Meetings Committee. The annual address of the President of the Society, Wayne H. Worthington, director of engineering research, John Deere Waterloo Tractor Works, will follow. Following Mr. Worthington's address, the winning paper in the ASAE Student Paper Award competition will be presented. Dalton S. Harrison, Everglades Experiment Station, will talk on mechanized agriculture in Florida's Everglades. The annual business meeting of the Society will follow. The ASAE Annual Dinner will be held at 6:30 p.m. in the Crystal Ballroom of the Hotel Roanoke.

The Soil and Water Division has extended its program one additional day to include problems of special interest in the development and maintenance of military and other grounds connected with public works projects. Representatives of the U.S. Army, U.S. Air Force, U.S. Navy, U.S. Department of the Interior, Civil Aeronautics Administration, Forest Service (USDA), Soil Conservation Service (USDA), and U.S. Department of Commerce have been invited to attend and participate in the meeting.

Power and Machinery Program

Byron T. Virtue, chairman, Power and Machinery Division, will preside at the first session of the division program on Monday forenoon, June 18. The program will open with a paper on the development of a sugar cane harvester, by R. M. Ramp, agricultural engineer, USDA, Houma, La. H. P. Smith, professor of agricultural engineering, A & M College of Texas, will conclude the session with a paper on the development of the mechanical cotton stripper. No program is scheduled for Monday afternoon.

Roy Bainer, junior past-chairman of the Division and president-elect of ASAE, will preside at the Tuesday morning session. Dean E. Booster, Oregon State College, will talk on electrostatic seed separation. He will be followed by Kenneth L. Hertel, physicist, University of Tennessee, who will present a paper on cotton fiber testing instruments and their development. To complete the Tuesday morning session, H. T. Barr, head, agricultural engineering research, Louisiana Experiment Station, will present a paper on anhydrous ammonia application equipment and testing laboratory.

Presiding at the Wednesday morning program will be L. G. Kopp, vice-chairman, ASAE Power and Machinery Division. Harlan W. Van Gerpen, John Deere Waterloo Tractor Works, will present a paper on instrumentation for evaluating seating comfort on farm tractors. C. W. Suggs and W. E. Splinter, associate professors of research, North Carolina State College, will present a paper on time and effort evaluation of agricultural tasks. After an intermission, F. A. Kummer, head, department of agricultural engineering, Alabama Polytechnic Institute, will present a paper on field layout for mechanization in the Southeast. It will be followed by a report of a survey of machinery requirements for soil and water conservation by T. W. Edminster, agricultural engineer (ARS), USDA.

On Wednesday afternoon, June 20, a joint meeting will be held with the National Joint Committee on Grassland Farming. Wayne H. Worthington, director of engineering research, John Deere Waterloo Tractor Works, will preside. Principal speaker for the program will be the Honorable True D. Morse, Under Secretary of Agriculture, who will talk on the subject of soil banks for more profits. Other papers to be presented during the joint meeting include seed and rootbed preparation for meadow crops by J. A. Slipher, Ohio State University; establishment of forage crops by J. L. Haynes, Ohio Agricultural Experiment Station; and removal of grass silage from horizontal silos by M. L. Esmay, Michigan State University and D. B. Brooker, University of Missouri.

Soil and Water Program

Wayne D. Criddle, chairman, irrigation group, Soil and Water Division, will preside at the opening session of the Soil and Water Program on Monday forenoon, June 18.

The session's theme is on small irrigation projects. Fred Larson, head, engineering and watershed planning unit, SCS, USDA, Upper Darby, Pa., will present a paper on existing state water legislation and that needed to develop small irrigation projects in the humid areas. Jay M. Bagley, assistant professor of irrigation and drainage engineering, Utah State Agricultural College, will talk on organizing for community sprinkler systems. The final paper for the morning session will be presented by L. R. Swarner, agricultural engineer, U. S. Bureau of Reclamation, on special problems of design, water delivery and inherent losses with community sprinkler systems. No program is planned for Monday afternoon.

A hydrology session is scheduled for Tuesday morning. Howard Matson, chairman, hydrology group, ASAE Soil and Water Division, will preside.

The first paper will be presented by Fred W. Blaisdell and Charles A. Donnelly, hydraulic engineers, St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minn., on the subject of the hood inlet for closed conduit spillways and culverts. Roy G. Andrews, SCS, USDA, Fort Worth, Texas, will present a paper on probability analysis of runoff data. The final paper of the session will be presented by P. R. Nixon and Glenn O. Schwab, Iowa State College, on water-yield prediction based on watershed characteristics.

Keith H. Beauchamp, SCS, USDA, will preside at the Wednesday morning drainage session. Surface drainage in the Mississippi Delta and Gulf Coast Plains, will be the subject of a paper presented by Irwin L. Saveson, A. M. Gibson, and K. V. Stewart, all of the USDA. R. L. Green, E. A. Schlaut, and Simon Krock, also of the USDA, will report on drainage in the lower Southeastern coastal plain. After a short intermission, Paul D. Doubt and Gerald E. Oman, civil engineers, SCS, USDA, will speak on routing flows through tide gates.

John R. Carreker, chairman, erosion control group, ASAE Soil and Water Division, will preside at the Wednesday afternoon erosion control session.

A symposium on water rights in the eastern United States is scheduled to highlight the afternoon session. Water rights in the eastern United States will be discussed by H. N. Young, director, Virginia Agricultural Experiment Station. Developing water rights legislation within a state, will be discussed by Cecil W. Chapman, state conservationist, USDA. A paper on seasonal aspects of surface losses in the middle coastal plain of Georgia by George N. Sparrow, ARS-SWC, and R. L. Carter, Coastal Plain Experiment Station, Tifton, Ga., will follow the symposium.

A special soil and water program for public lands and public works will be presented on Thursday, June 21. C. L. Hamilton, office of consultant, soil conservation and erosion control, Bureau of Yards & Docks, U. S. Navy, will preside at the morning session.

An introduction by Captain John A. Stelger, assistant chief, Bureau of Yards & Docks Planning and Design, U.S. Navy, will begin at 8:30 a.m. A symposium on soil conservation and land management is planned and will include the following participants: F. E. Rutt, Office, Assistant Secretary of Defense, will speak on maintaining military lands; W. J. Endersbee, Office of the Secretary, Department of the Interior, will discuss rehabilitation of public and Indian lands; Burton F. Kiltz, U.S. Army, will describe maintenance planning for army building areas; Cyril B. Webster, U.S. Army, will talk about managing military woodlands; and L. B. Bassett, District Public Works Office, Ninth Naval District, will cover outleasing Navy lands.

After a short intermission a paper on recent developments in hydraulic design of highway bridges and culverts by Carl F. Izzard of the U.S. Department of Commerce, will be presented and discussed. The concluding paper of the morning session will be on highway erosion control development by Frank H. Brant, North Carolina State Highway and Public Works Commission.

On Thursday afternoon, June 21, F. E. Rutt, of the office of the Assistant Secretary of Defense, will preside. Willis Skrdla, Tactical Air Command, Langley Air Force Base, will speak on developing and maintaining airfield runway shoulders. Ralph G. Nevins, Kansas State College, will follow with a paper on research findings on jet blast erosion along airfield runways. After a short intermission, a soil conservation symposium on earth covered structures will be presented. Speakers and topics of discussion for the symposium include: Vance Mays, Office, Chief of Ordnance, U.S. Army, will talk on vegetation management for earth-covered structures in humid areas; Edward H. Doll, SCS, USDA, will discuss special vegetation for earth-covered structures in semiarid areas; H. E. Dekker, Twelfth Naval District, will describe erosion protection for earth-covered structures in arid areas; and Hinson C. Cole, First Naval District, will speak on the construction and maintenance relationships for earth-covered structures. Following the symposium, Lawrence E. Tull, U.S. Navy, will present a paper on Navy grounds maintenance.

Farm Structures Program

C. F. Kelly, chairman, ASAE Farm Structures Division, will preside at the Monday morning, June 18, session. G. L. Hazen, director of research, James Mfg. Co., will present a paper on mechanization of the poultry house. S. A. Hart, assistant agricultural engineer, University of California, will lead a discussion on the paper. Mechanical aeration of grain in large storages, is the subject of the second paper presented by Leo E. Holman, agricultural engineer, USDA. W. V. Hukill, USDA, will lead discussion on the paper. The final paper for the morning session will be on new developments in self-feeding silos by Mark E. Singley, associate professor, Rutgers University.

T. E. Long, chairman, Steering Committee, ASAE Farm Structures Division, will preside at the Tuesday morning session. The theme for the session is entitled "Farm Building Construction." Plastic films in farm construction by C. E. Staff, Bakelite Co., is the first paper on the Tuesday morning program. R. L. Perry, University of California, will discuss the paper. M. A. Sharp, head, department of agricultural engineering, University of Tennessee, will present a paper on a concrete block house using liquid adhesives. A report on farm structures research needs by Wallace Ashby, chairman, ASAE Farm Structures Research Needs and Statistics Committee, will conclude the morning program.

Farm housing will be the theme for the Wednesday morning session of the Farm Structures Division. F. J. Reynolds, vice-chairman, ASAE Farm Structures Division, will preside. F. A. Kummer, head, agricultural engineering department, API, will present a paper on rural housing research in the Southeast. Price Hobgood, professor, A & M College of Texas, will discuss the paper. H. J. Thompson, ARS, USDA, Beltsville, Md., will present a paper on moisture transfer in concrete slab floors, and Harry H. Steidle, Prefabricated Home Manufacturers Institute, will present a paper on progress in home prefabrication to complete the Wednesday morning program.

On Wednesday afternoon, the Farm Structures Division will hold a joint meeting with the Rural Electric Division. R. E. Stewart, professor of agricultural engineering, University of Missouri, will preside.

H. K. Lee, The Johns Hopkins University, will speak on the physiology of livestock in hot humid climates. The second paper will be on cooling livestock with fans by T. E. Bond, ARS, USDA, Davis, Calif.; C. F. Kelly, University of California; and N. R. Ittner, Imperial Valley Field Station. A progress report on cooling by refrigeration will be presented by E. A. Kazarian, Michigan State University. C. E. Brunson, Louisiana State University, will speak on controlled temperatures for poultry. A general discussion and summary by R. E. Stewart will follow.

Rural Electric Program

William G. Buchinger, member, Program Committee, ASAE Rural Electric Division, will preside at the Monday morning, June 18, session. The first paper is on new developments in measurement of milk in bulk tanks, by Allen K. Gillette and Carl W. Hall, Michigan State University. Other papers on the morning program include new developments in farm lighting by J. P. Ditchman, General Electric Co.; farm wiring motivation studies by J. C. Cahill, the Detroit Edison Co.; a report of the Animal Shelter Ventilation Committee by H. N. Stapleton, Shelburne Farms, Shelburne, Vt., and dollars and cents in farm electrification by James H. Oliver, General Electric Co.

Ross R. Mauney, vice-chairman, ASAE Rural Electric Division, will preside at the Tuesday morning session. A review of current research activities at the state experiment stations on the application of electricity to agriculture will be presented by Barton C. Reynolds, USDA. T. E. Hienton, head, farm electrification section, USDA, will discuss USDA cooperative farm electrification research at the state experiment stations. Discussion will be lead by W. J. Ridout, Jr., editorial director, Electricity on the Farm Magazine. Some methods and equipment for irradiating seed with low energy levels will be presented by R. B. Stone and O. A. Brown, agricultural engineers, USDA. R. C. Nicholas and D. E. Wiant, Michigan State University, will present a paper on the effect of high velocity electron irradiation on certain farm products.

H. S. Pringle, chairman, ASAE Rural Electric Division, will preside at the Wednesday morning session. The first paper on the program is on electric underheat brooding, by J. H. Hough, National Lumber Mfrs. Assn. It will be followed by a paper by Olin W. Ginn, Georgia Power Co., on electricity versus bottled gas for commercial broiler production. A paper by Ross R. Mauney, Arkansas Power and Light Co., on portable slab type brooder will follow. After a short intermission, W. A. Junnila, USDA, University of Connecticut, will present a paper on poultry water warming. The final paper for the Wednesday afternoon program is on basic cooling and moisture loss characteristics of eggs by S. M. Henderson, University of California.

On Wednesday afternoon a joint meeting will be held with the farm structures division. See the farm structures program for details.

Education and Research Program

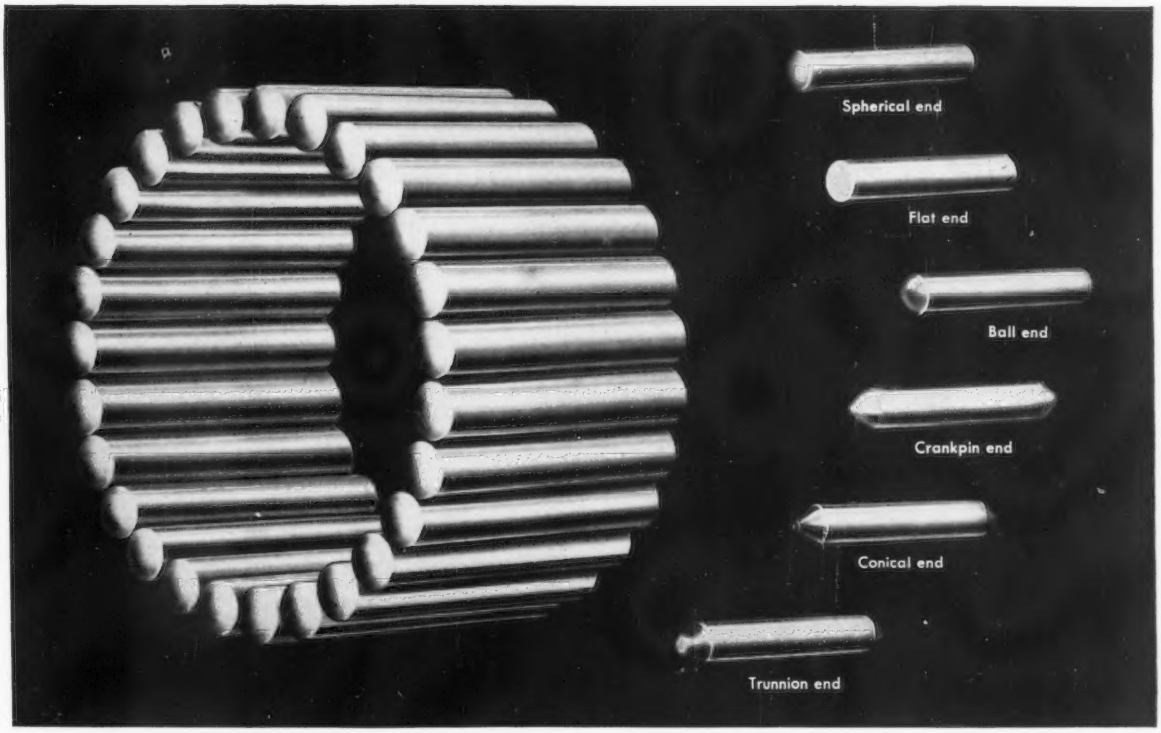
Carl W. Hall, chairman, ASAE Committee on Agricultural Processing, will preside at the first session of the opening session, Monday, June 18. The chosen theme is Processing in the Agricultural Engineering Curriculum. The first speaker on this program will be S. Milton Henderson, University of California, who will speak on teaching procedures for process engineering. The second paper will be on a teaching program in agricultural processing by G. W. Isaacs, Purdue University. Jordan H. Levin and Carl W. Hall, respectively, USDA and Michigan State University, will talk on postwar agricultural engineering.

The second session is scheduled for Wednesday morning, June 20. F. A. Kummer, chairman, ASAE Education and Research Division, will preside. The first paper on the program will be on course content in agricultural engineering curricula by W. M. Carleton, Michigan State University. E. W. Schroeder, Oklahoma A & M College, will follow with a paper on what constitutes a PhD program in agricultural engineering. A discussion of this paper will be lead by W. M. Carleton.

National Joint Committee on Grassland Farming Program

The first session of the Committee will be held Wednesday morning, June 20. Howard B. Sprague, head, department of agronomy, Pennsylvania State University, will preside. The first paper will be on planning a balanced farm forage program by R. E. Blaser, Virginia Polytechnic Institute. The basic concepts of hay drying will be discussed by Mark E. Singley, Rutgers University. W. A. Raney, Mississippi State College, will present a paper on the place of irrigation in grassland farming. A panel discussion by a group of farm operators will

(Continued on page 374)



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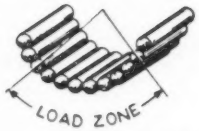

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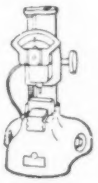

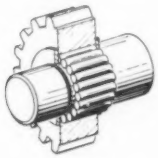

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TORRINGTON BEARINGS

90th ANNIVERSARY 1866–1956

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Lester G. Kopp has been promoted from chief engineer to plant manager, and **Donald E. Kuska** has been promoted from assistant chief engineer to chief engineer, of the South Bend, Ind., Plant No. 1 of The Oliver Corporation.

Mr. Kopp joined Oliver in 1948 as assistant chief engineer of the South Bend plant, and in 1951 he was made chief engineer. Previously he had been employed in an engineering capacity with both David Bradley Mfg. Co. and Harry Ferguson, Inc. Mr. Kopp is presently vice-chairman of the ASAE Power and Machinery Division, and will automatically become chairman of the Division next month.

Mr. Kuska has been in the company's tillage implement plant since 1950 and was appointed assistant chief engineer in 1951.

•

Robert W. Powell has been promoted recently from Chicago regional manager, to general sales manager of the Fafnir Bearing Co., New Britain, Conn.

Mr. Powell joined Fafnir in 1924. He served subsequently in the company's Boston office and as district manager of the Cleveland office. In 1936 he became head of the company's Chicago sales territory which includes branch offices in Minneapolis, Milwaukee, and Moline, Ill. He will take up his new duties in New Britain about June 1.

Succeeding Mr. Powell as Chicago regional manager will be **Chauncey W. Olson**, Moline district manager since 1952. With the company since 1935, Mr. Olson previously was district manager of both the Denver and Minneapolis offices.

•

Donald S. Horne has joined Motor Wheel Corp., Lansing, Mich., as a sales representative for the company's agricultural and industrial division. He will represent the company in the eastern United States and eastern Canada. Prior to joining Motor Wheel, he served Cockshutt Farm Equipment, Ltd., Ontario, as chief engineer in charge of its harvester combine division.

•

A. S. Marlow, Jr., has announced his resignation from Bell & Gossett Co., as vice-president and general manager and a director of the Marlow Pumps Division. The move was prompted, he said, by the increasing scope of other interests which have developed so rapidly that they now require his complete time and attention.

•

L. H. Schoenleber, engineer, supervising testing and research work at the central testing laboratory, J. I. Case Co., has been made chief experimental engineer in charge of dynamometer research and field testing at the Tractor Works, Racine, Wis. Operations of the central testing department along with testing and research work at the Tractor Works have been consolidated.

•

Deane G. Carter, Life Fellow ASAE and professor of farm structures at the University of Illinois, has been appointed coordinator for the University's International Cooperation Administration programs. Professor Carter will retain academic rank in the department of agricultural engineering but in the new assignment he will be associated with the office of the Provost on a full-time basis.

In his new work he will be in charge of four contracts with the I. C. A. Three contracts deal with programs in India, while the fourth is concerned with housing in Colombia, South America.

ASAE MEMBERS in the News

L. G. KOPP

R. W. POWELL

D. E. KUSKA

C. W. OLSON

D. S. HORNE

A. S. MARLOW, JR.

Robert H. Brown, associate professor of agricultural engineering, University of Georgia, was recently awarded a Danforth scholarship to take advanced study at an institution of his choosing. He was selected as one of 60 from over 600 applicants in a nationwide competition. Not only was he the only agricultural engineer, but he was the only engineer selected.

•

Loy L. Sammet was recently awarded a Certificate of Merit by the Agricultural Marketing Service, U. S. Department of Agriculture, for outstanding leadership in the development and application of economic and engineering research techniques to the problems of evaluating costs and efficiency of fruit and vegetable packing and processing operations. Since September, 1949, Mr. Sammet has been engaged in this research which is being carried out by the California Agricultural Experiment Station and the market organization and costs branch, Agricultural Marketing Service, USDA.

•

Ralph L. Oyler, former owner of Farm Implement Sales and Service, St. Thomas, Pa., is now employed as product analyst in the product planning and programming department, Thractor and Implement Div., Ford Motor, Co., Birmingham, Mich.

Biswa N. Ghosh has returned to his home in India after completing requirements for a Ph.D. degree in agricultural engineering from King's College, Newcastle-on-tyne, University of Durham, U. K. He began his post-graduate studies in 1953 under a Burmah-Shell scholarship granted by the Council of Scientific and Industrial Research, Government of India, New Delhi. He prepared his thesis on an investigation into the power requirement of a rotary cultivator.

•

Robert M. Rae has announced that he is leaving the department of agricultural engineering, Allahabad Agricultural Institute, District Allahabad, U. P., India, and will return to Canada. His new address will be 655 Gilmour St., Ottawa, Ontario.

•

Earl D. Hansen has returned from military service and is employed as an engineering trainee at the John Deere Waterloo Tractor Works, Waterloo, Ia.

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David C. Horney, formerly on duty with the armed services, is now employed as a student engineer, John Deere Waterloo Tractor Works Waterloo, Ia.

•

Pierre E. Maitin, former soil conservation engineer, soil conservation section, Department of Agriculture, Nicosia, Cyprus, has accepted a position with the federal service in the new Federation of Rhodesia and Nyasaland. His new address will be Cairo Road, Lusaka, Northern Rhodesia.

•

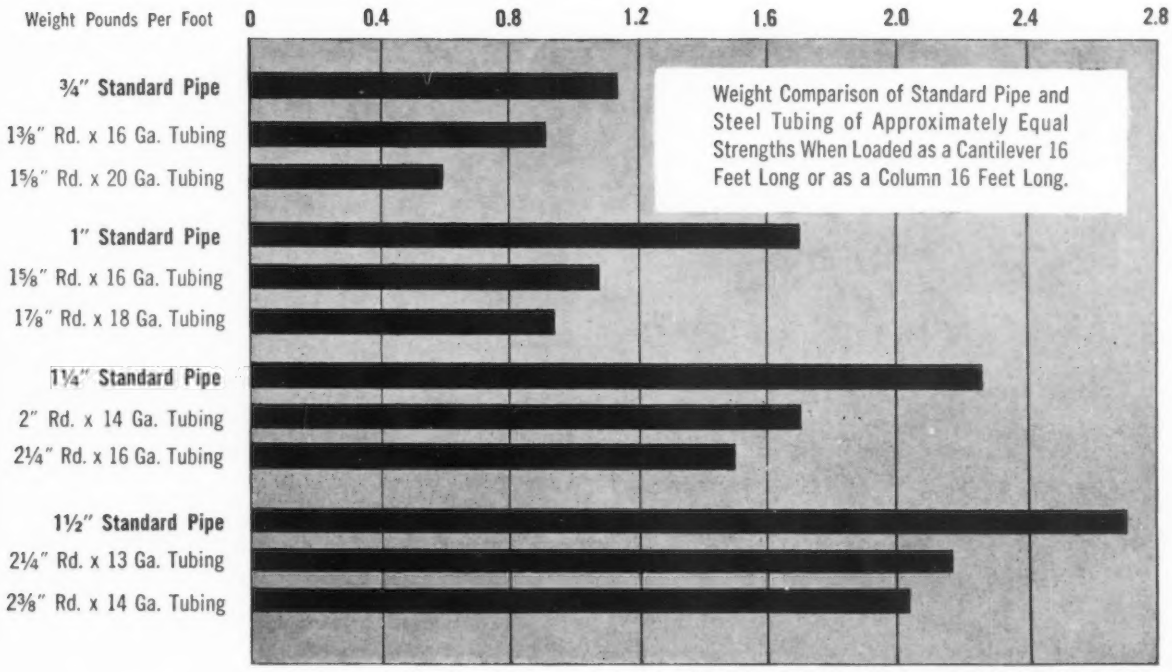
W. A. Pohlman recently resigned his position as field engineer of Gardner Manufacturing Co. and has taken up residence at his farm near Muscatine, Iowa, where he will continue his work on black light as it affects the behavior of phototropic insects.

•

Oscar W. Sjogren, a past-president of ASAE, has announced that he will complete his assignment with the European Productivity Agency in Paris, France, soon and plans to return to his home in California. He has been in France since early in November as a consultant in farm mechanization. His work consisted of assisting in conducting seminars or conferences and making surveys to collect data that may be used in formulating training programs for tractor and farm machinery operators.

NECROLOGY

W. H. Harstick, chief advanced engineer, farm implements, Memphis Works, International Harvester Co., died March 20. He was born in Illinois in 1896. Upon completion of high school, he took his first employment as a tool making trainee with the Willys-Overland Co. Three years later he became a tool maker for the Rock Island Arsenal in Rock Island, Ill. In 1922 he became product designer and manufacturer of wind electric plants at Woodmanse Mfg. Co., Freeport, Ill., and in 1925 he became foreman of the magneto dept., Fairbanks Morse Co., Beloit, Wis. In 1933 he joined International Harvester Co. as product engineer of dairy equipment. In 1939 he became chief engineer of dairy equipment, where he designed the "S" line cream separators and the power washing cream separator made by International Harvester Co. In 1954 he moved to Memphis to assume the position he held until his death.


Weight Pounds Per Foot
0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
¾" Standard Pipe
1⅜" Rd. x 16 Ga. Tubing
1⅝" Rd. x 20 Ga. Tubing
1" Standard Pipe
1⅝" Rd. x 16 Ga. Tubing
1⅞" Rd. x 18 Ga. Tubing
1¼" Standard Pipe
2" Rd. x 14 Ga. Tubing
2¼" Rd. x 16 Ga. Tubing
1½" Standard Pipe
2¼" Rd. x 13 Ga. Tubing
2⅜" Rd. x 14 Ga. Tubing
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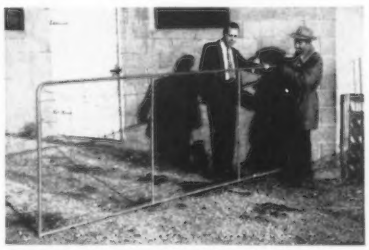

Farm gate frames are typical applications where weight reductions offer advantages. The gate shown here is 14 feet long, 48 inches high. It weighs only 60 pounds. The same size gate made with standard pipe of equivalent strength would weigh about 34% more.

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With the ASAE Sections

Tennessee Section

A meeting of the Tennessee Section will be held June 1 to 3 at Watts-Bar Resort Village, Spring City. Program information may be obtained by writing to James A. Lee, 115 S. Crest Rd., Apt. 5, Chattanooga, Tenn.

Connecticut Valley Section

A meeting of the Connecticut Valley Section will be held June 6. An interesting tour has been arranged, commencing at 2:00 p.m. at Stanley Noga's Turkey Farm in Palmer, Mass., to view turkey raising operations, killing, cold storage and modern sales rooms. At 3:30 p.m. the group will tour an apple processing and controlled atmospheric storage at Stacey Gay Farm in Three Rivers, Mass. A short business meeting is scheduled at 5:00 p.m. preceding a dinner at Liz's Cafe in Three Rivers. Dinner will be served at 5:30 p.m.

North Carolina Section

Ray M. Ritchie, Jr., agricultural extension engineer, North Carolina State College, was elected chairman of the North Carolina Section at a meeting held on the North Carolina State College campus, March 9 to 10. Other officers included John P. Dail, General Metals, Inc., Greensboro, N. C., as first vice-chairman; E. H. Frazier, Jr., Aeroglide Corp., Raleigh, N. C., as second vice-chairman; and Blaine F. Parker, agricultural engineering department, North Carolina State College as secretary and treasurer.

Papers and a round table discussion featured the technical sessions of the meeting, followed by a business session held on Saturday morning, March 10.

A chicken barbecue, bonfire, fox hunt and surprise award presentation were features of the March 9 evening program. The chicken barbecue supper was prepared and served at a farm yard about one hour's drive from the college campus. After the supper, by a large bonfire, came a surprise presentation of a distinguished service award from the Section to D. S. Weaver, director of agricultural extension in North Carolina, for his contribution to the agricultural engineering profession in the state. This was followed by a fox hunt staged by Warren Weldon, agricultural engineering department, N.C.S.C., and his own pack of hounds. The hunters report that one gray fox was caught and one red fox was chased into a den.

West Virginia Section

A meeting of the West Virginia Section was held at Farm Electrification Building, Jackson's Mill, W. Va., April 3. Present officers were re-elected for 1956 with the exception of Russell Gist, who is now on Foreign Service. Harold M. Rhodes, state conservation engineer, USDA, was elected vice-chairman to fill the vacancy. J. T. Reid will continue as chairman and J. T. Darby as secretary.

A. D. Longhouse, head, agricultural engineering, West Virginia University, Morgantown, W. Va., spoke on the proposed new agricultural engineering building for West Virginia University.

Mid-Central Section

Dale O. Hull, associate professor of agricultural engineering, Iowa State College, was elected chairman of the Mid-Central Section at a meeting at the Hotel Robidoux, St. Joseph, Mo., held April 6 to 7. J. L. Myers, Eastern Nebraska Public Power District, George H. Larson, Kansas State College, and Ralph L. Ricketts, University of Missouri, were elected as vice-chairmen. George M. Petersen, University of Nebraska, was elected secretary-treasurer. Harry F. Barton and Webb Embry were selected to serve on the arrangements committee for the 1957 meeting.

In a plan to promote increased membership within the Section, each member was asked to make a real effort to contact all agricultural engineers in the area who are not members of the Society. It was also suggested that high schools be contacted in an effort to interest and to inform high school boys about the Society and its activities.

A 3½-hour boat ride and inspection trip of the channel stability work being conducted by the Kansas City division of the Corps of Engineers was enjoyed by all. Wayne H. Worthington, ASAE president, spoke at the Friday evening dinner. The meeting adjourned at noon on Saturday.

Quad City Section

Roy E. Harrington, project engineer, product development department, Deere & Co., was elected chairman of the Quad City Section at the annual business meeting held April 20 at Johnny Hartman's Restaurant, Davenport, Ia.

Edward G. Rowlett, district engineer, The Torrington Co., and Gerald W. Berryhill, project engineer, J. I. Case Co., were elected as vice-chairmen. The new secretary is Mahlon L. Love of the engineering department of John Deere Harvester Works, and the new treasurer is Bruce A. Genzel, district sales engineer, Chain Belt Co. The new nominating committee consists of D.O.H. Miller, sales engineer, Chicago Rawhide Mfg. Co.; Charles S. Morrison, chief engineer, product development department, Deere and Co.; and William L. Stevenson, junior engineer, J. I. Case Co.

The program began with a tour of the International Harvester Company's Farmall Tractor Works at Rock Island, Ill. It was followed by a program consisting of a paper on the evolution of a planetary transmission by Howard W. Simpson, consulting engineer, Dearborn, Mich., and a paper on the combustion gas turbine—theory and application by M. M. Weiner, product planner, gas turbine dept., General Electric Co.

The Section dinner was held in the evening after a courtesy cocktail hour. Attendance was 210.

J. L. Butt, executive secretary of ASAE, addressed the group on the subject of what it takes to make ASAE strong. The annual business meeting followed.

Southwest Section

Xzin McNeal, professor of agricultural engineering, University of Arkansas, has been elected as chairman of the Southwest Section at a Section business meeting in Texarkana, March 3. He succeeds C. V. Phagan, extension agricultural engineer, Oklahoma A. & M. College. Charles E. Ball, associate editor, *Farm Journal*, is the new vice-chairman, and W. H. Carter, professor of agricultural engineering, Louisiana State University, is the new secretary.

An interesting program preceded the business meeting. On Friday, March 2, papers were presented during an all-day session. In the evening the annual dinner was held with Wayne H. Worthington, president of ASAE, as speaker. The meeting adjourned at the conclusion of the morning session on Saturday, March 3.

ASAE Quad City Section officers at the annual meeting of the Section April 20. *(Left to right)* M. L. Love, secretary; E. G. Rowlett, vice-chairman; R. E. Harrington, chairman; G. W. Berryhill, vice-chairman; and M. E. Weakly, 1955-56 chairman

ASAE North Carolina Section officers at the annual meeting of the Section March 10. *(Left to right)* R. M. Ritchie, Jr., chairman; J. P. Dail, first vice-chairman; and B. F. Parker, secretary and treasurer

Quality components

MAKE GOOD PRODUCTS EASIER TO SELL

...so in advertising and literature, these machinery builders feature

✓BLOOD BROTHERS Universal Joints and Drive Lines

Doctor, Merchant or Chief Engineer, you learn to prefer well-known products of high reputation—whether tires for your family car or component parts for your products.

These farm machinery manufacturers, too, have learned from past satisfaction that customers *respect and prefer to buy* implements with Blood Brothers Universal Joints.

So in catalogs and advertising, they *voluntarily* feature the dependable, uniform high quality of Blood Brothers Drive Lines.

Engineer, Purchasing Agent or Salesman—*you'll* find good products get extra preference (and perform better too) when they're Blood Brothers' equipped!

Write for engineering data and "Spec Sheet" Blanks.

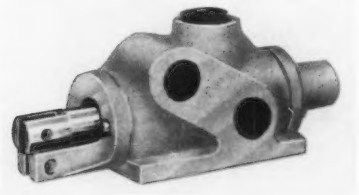
BLOOD BROTHERS
MACHINE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

NEW PRODUCTS CATALOGS

Four-Way Hydraulic Valve

Wisconsin Hydraulics, Inc., 3165 N. 30 St., Milwaukee 16, Wis., has developed a new heavy-duty, 4-way, hydraulic valve for units up to 20 gpm. The valve features a



built-in pressure relief on the tank side. Direct mounting on reservoir-return ports feeds back directly to reservoir, eliminating return lines.

Designed and engineered for farm and road building machinery and truck mounted equipment, the new valves are illustrated and described in a new folder, No. V-1, available from the company.

Anhydrous Ammonia Hose Line

Aeroquip Corp., Jackson, Mich., has announced a new, long-life hose line for the safe transfer of anhydrous ammonia. The hose operates at 350 psi in accordance with the proposed specifications of the Agricultural Ammonia Institute.

The hose consists of a thick synthetic inner tube that minimizes diffusion of am-

monia gas. The outer cover, also of synthetic rubber, allows fast diffusion of the gas, eliminating cover blisters. A double rayon braid reinforcement, impervious to the effects of the gas, is embedded between the inner tube and cover.

Plastic Fertilizer Hopper

International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill., has announced new fertilizer hoppers made of Fiberglas reinforced with plastic. The new plastic hopper reportedly will not corrode from weather or prolonged contact with fertilizer. It is made of translucent material and the fertilizer level can be seen through the hopper wall.

The hopper bottom has a new rotary gate-type fertilizer regulator, designed to

meter fertilizer accurately over the full range of distribution from 25 to 1,600 lb per acre. Hopper capacity is 115 lb.

Self-Lubricating Chain

Whitney Chain Co., Hartford, Conn., has introduced a new self-lubricating agricultural chain. In the new chain, sintered-steel bushings replace conventional chain rollers. Each sintered bushing is in effect a built-in oil reservoir. When the chain is in operation, lubricant within the bushing is heat expanded and thus caused to flow over the bearing surfaces in quantity adequate for

lubrication at all temperatures and loads. Upon encountering diminishing temperatures, the lubricant contracts and thereupon is reabsorbed by the sintered bushing. This cycle recurs throughout the operational life of the chain.

The manufacturer reports that the new chain is interchangeable with American Standard and double-pitch roller chains of the same pitch, and it operates over the same sprockets. The transmission chains have contour side plates for maximum sprocket clearance. The conveyor chain has heavy, straight side plates for maximum support in conveyor operation.

Auger-Type Mechanical Feeder

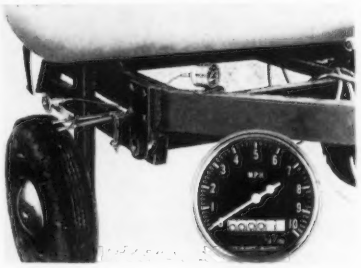
Clay Equipment Corp., Cedar Falls, Iowa, has introduced a new auger-type mechanical feeder, which can be adapted to most existing feed bunks. The only requirement

is that the bunks should be at least 42 in wide.

It is reported that the new feeder can fill 50 ft of bunk in about 15 min. Distribution of feed along the bunk is even and smooth, even on curves where the feeder makes a change of direction. It will handle all types of silage, shelled corn, small grains and supplements. The action of the auger is said to help mix supplements with the basic ration.

Handy Farm Speedometer Kit

The Instrument Division, Stewart-Warner Corp., 1826 Diversey Pkwy., Chicago 14, Ill., has developed a speedometer kit for coordinating over-the-ground speed of farm



equipment with the flow of anhydrous ammonia.

With the new speedometer, the operator can tell the exact speed of the applicator rig at all times and adjust the speed of travel or flow rate of the NH_3 to secure the desired degree of concentration.

Installed either on the tractor or rig, the speedometer registers the actual speed and total distance travelled regardless of varying tire sizes, gear ratios or slippage. It also is handy for measuring the total area covered even though the fields might be hilly, contoured or irregularly shaped. The kit contains a speedometer head, 9-ft flexible shaft, a mounting clamp, and a support rod and drive assembly.

Fastener Catalog

Clark Bros. Bolt Co., Milldale, Conn., has issued a new 44-page catalog covering the company's line of bolts, nuts, rivets, screws and other industrial fasteners. The catalog contains illustrations, sizes, packaging information and prices. A free copy may be obtained by writing directly to the company.

New Type Corn Harvester

Tractor and Implement Div., Ford Motor Co., Birmingham, Mich., has announced production of the new two-row mounted corn harvester that uses a new snapping-roll principle which snaps the ears to the side, dropping them directly onto the corn elevator. According to the company, the new snapping principle, plus a quartz-coated or rubber snapping roll insert, reduces field loss by as much as 50 percent. The new 2-row mounted harvester, designed for use in those areas where it is desirable to leave the husks on the ears, is one of six corn harvesting and picking machines in the Ford line. A detailed account of develop-

ment of the new harvester appeared as a feature article in the February issue of AGRICULTURAL ENGINEERING.

(Continued on page 364)

"Our bulk milk tank will pay for itself in two years"

says Mrs. Oscar Gunderson, Cambridge, Wisconsin

The Gundersons have 40 Holsteins milking, and the output is about 1600 pounds a day. The milk is stored in a 300-gallon, refrigerated Stainless Steel tank, which is emptied by a tank truck every day.

For their bulk milk the Gundersons have been receiving a premium of 25¢ per cwt., plus a 5¢ reduction in the hauling cost. Butterfat is higher: it used to be around 3.4, but now averages between 3.5 and 3.6.

Since installing a bulk tank, milk quality has been consistently good. "Blue" test has been eight hours or longer.

All in all, Mrs. Gunderson thinks that the tank will pay for itself in just two years; and she estimates that she and her husband save about one hour of hard work every day.

Send the coupon for an informative booklet that answers many of your questions about bulk milk handling with Stainless Steel refrigerated storage tanks.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · PIPE · TUBES · WIRE
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Agricultural Extension
United States Steel Corporation, Room 5344
525 William Penn Place, Pittsburgh 30, Pa.

Please send me the free booklet on bulk milk handling equipment.

Name .....

Town ..... RFD .....

County ..... State .....

UNITED STATES STEEL

DURKEE-ATWOOD's *Little Professor reports . . .*

"Sugarbeets...1000's of 'em...

harvested *automatically* with BLACKWELDER'S amazing MARBEET HARVESTER... for as little as 45¢ per ton!"

One man . . .

harvests 3 to 5 acres per day . . .

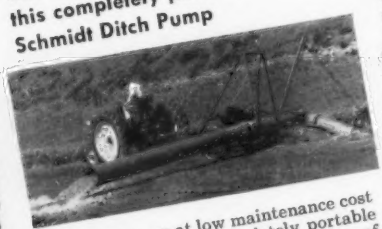
delivering up to 100 tons . . .

of *clean topped* beets!

The MARBEET Sugarbeet Harvester uses DURKEE-ATWOOD V-belts!

Blackwelder engineers saved beet farmers plenty of money when they designed the MARBEET. Now in use across the U.S. and abroad, this rugged machinery harvests *all* the beets, large and small, and delivers them *clean*. The MARBEET's unique power transmission and take-off network calls for top-flight performance. That's why Blackwelder engineers called on Durkee-Atwood for assistance in designing the rugged but gentle, foolproof and efficient transmission system. And that's why the MARBEET uses tough, long-lasting Durkee-Atwood V-belts exclusively . . . to keep beet harvesting costs low . . . even under wet and adverse conditions. Call on D-A . . . let Durkee-Atwood V-belt engineers help *you* with tough transmission problems.

Blackwelder Engineers also use Durkee-Atwood V-belts for this completely portable Schmidt Ditch Pump



High efficiency at low maintenance cost is achieved in this completely portable self-contained unit through the use of Durkee-Atwood Multiple V-belts. One man can set up the pump in 5 minutes anywhere, ready to deliver up to 3200 G.P.M. from depths varying from 3 to 9 feet. Another example of how Durkee-Atwood V-belts help deliver peak performance. Let D-A engineers help *you* with *your* transmission design.

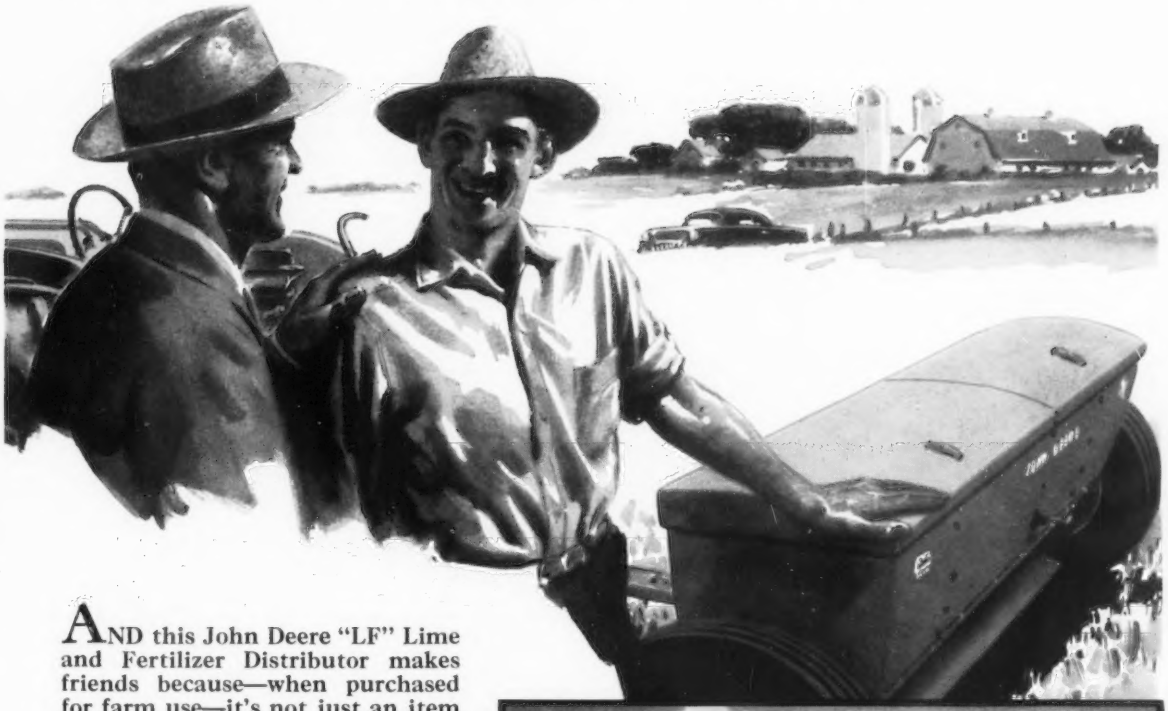
ATTENTION AG. ENGINEERS—

Get your FREE copy of "Handy Tips on V-belts and V-belt drives"

See your D-A distributor or write Dept. AE-5 for catalog that includes conversion tables, engineering data, latest Rubber Manufacturers Association horsepower ratings, drive selections and helpful Do's and Don'ts of V-belt operation.

DURKEE-ATWOOD
COMPANY
• Minneapolis 13, Minnesota

"It's the Kind of Implement That Makes a Customer a 'Friend' . . ."



AND this John Deere "LF" Lime and Fertilizer Distributor makes friends because—when purchased for farm use—it's not just an item of expense, *it's an investment*. It's a wise investment and a necessary one for almost any farm's soil conservation program.

In today's farming, the Lime and Fertilizer Distributor is as important as the manure spreader, or the crop rotation, or terracing.

Actually, this "Propel-R-Feed" Distributor is a new machine—new to meet the needs of the new modern farmer.

And this new machine is representative of the ever-modern John Deere line of quality farm equipment—the kind of equipment that does a job right and benefits its owner by enriching the soil, producing bigger yields, and saving time and money.

Farm equipment that will do all this will make *any customer a friend.*

Farmers everywhere are finding the John Deere "Propel-R-Feed" Distributor the ideal machine for liming and fertilizing pastures, hayfields, and prepared seedbeds; seeding small grain; and making a one-operation job of fertilizing and planting all kinds of legumes and grasses.

JOHN DEERE • Moline, Illinois

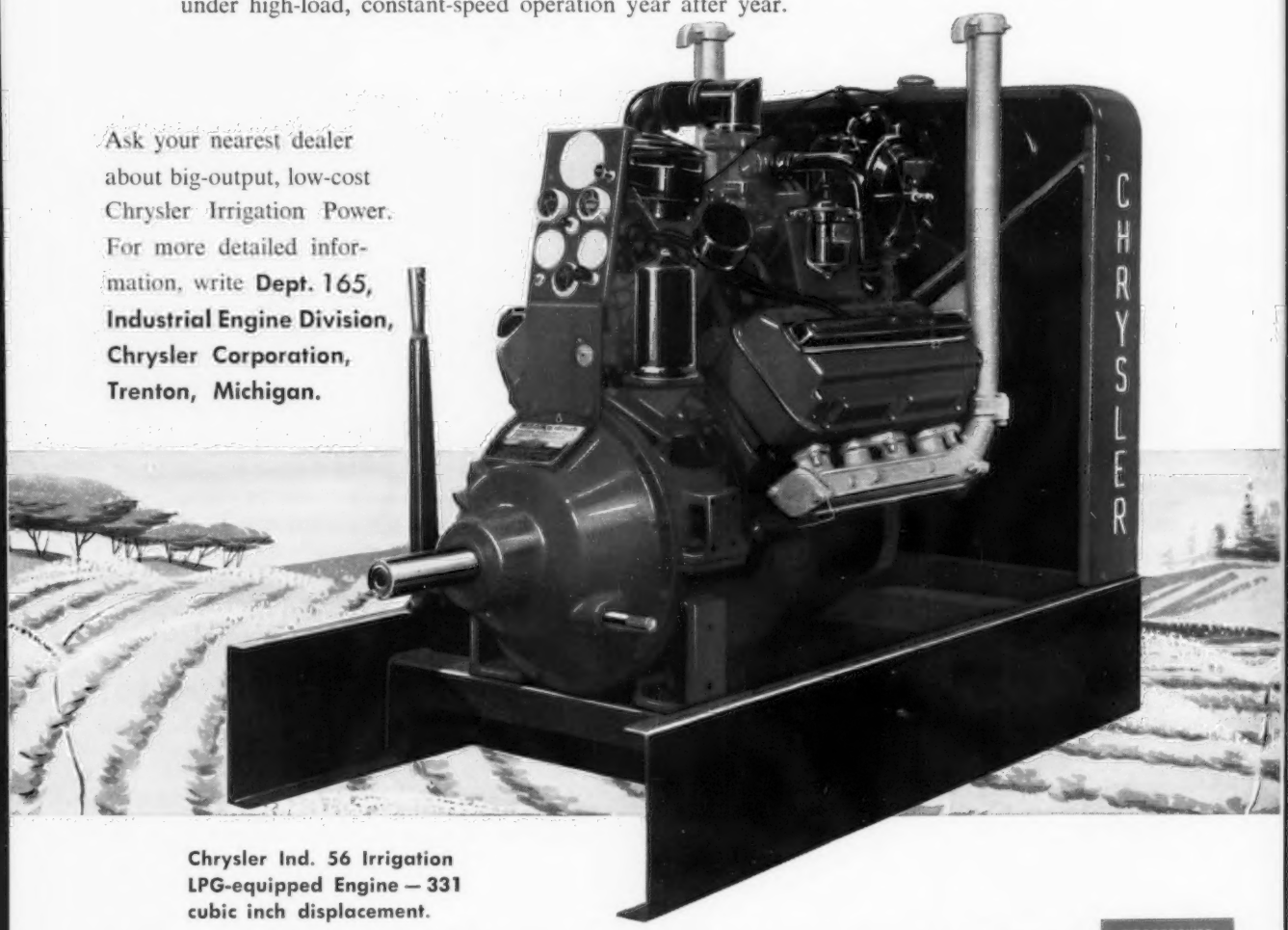
QUALITY FARM EQUIPMENT SINCE 1837

CHRYSLER IRRIGATION POWER

delivers greater output at lower cost

Real workhorse power — that's what a Chrysler V-8 Industrial Irrigation Engine gives you! It pumps more gallons per minute than any other engine in its class. And it costs less than any other industrial engine even close to its power range. Costs less to operate, too – whether you use gasoline, natural or L-P gas. Maintenance costs are also much less – because this Chrysler Engine is designed and built especially for irrigation. Valves, crankshaft and bearings, for example, are engineered to stand up under high-load, constant-speed operation year after year.

Ask your nearest dealer about big-output, low-cost Chrysler Irrigation Power. For more detailed information, write **Dept. 165, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.**



Chrysler Ind. 56 Irrigation LPG-equipped Engine – 331 cubic inch displacement.

CHRYSLER INDUSTRIAL ENGINES

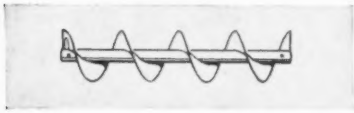
HORSEPOWER WITH A PEDIGREE

INDUSTRIAL ENGINE DIVISION / CHRYSLER CORPORATION

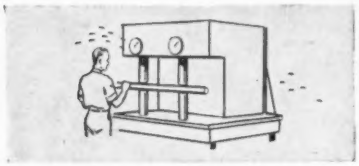
Flexible in application . . . versatile in operation

Link-Belt augers simplify design

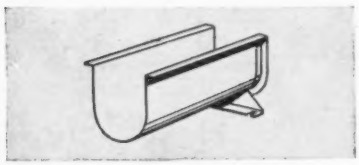
SELECTED FLIGHTING for all your auger needs. Helicoid, sectional or a range of other types of flighting are available in the metal and finish best suited for your design.



SIMPLICITY OF CONSTRUCTION and sturdy design of Link-Belt augers provide dependable, efficient operation on your machine. One basic assembly with no other moving parts to break down.



YOUR CHOICE OF METALS answers your requirements for handling corrosive or abrasive materials. And Link-Belt uses only specially selected steels to assure a uniform product.



ALL COMPONENTS — conveyor screws, collars, couplings, hangers, troughs, trough ends, flanges, drives —are available for every design.

ENGINEERING SERVICES. Our auger specialists will help you analyze your special needs . . . integrate all elements of your design.

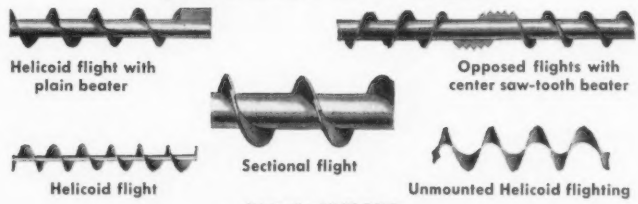
Four Link-Belt auger-conveyors on cotton-stripper provide positive, unobstructed delivery of bolls to kick-beaters. This is just one of the many applications for the full range of augers developed by Link-Belt.

You can be sure of efficient operation, long life and low maintenance when you make a Link-Belt auger part of your equipment.

Link-Belt has a wide selection of augers, many of a specialized design, in a full range of diameters, gauges and pitches. They're accurately made to assure easy assembly, smooth, dependable operation. In addition, all components can be adapted to your particular design.

Whether it's a new application for your present machines or an entirely new concept, simplify your design problems by specifying Link-Belt augers. Call your nearest Link-Belt office for complete information.

Typical LINK-BELT augers



Write for LINK-BELT Screw Conveyor Book 2289

LINK-BELT

FARM MACHINE AUGERS

14.057

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

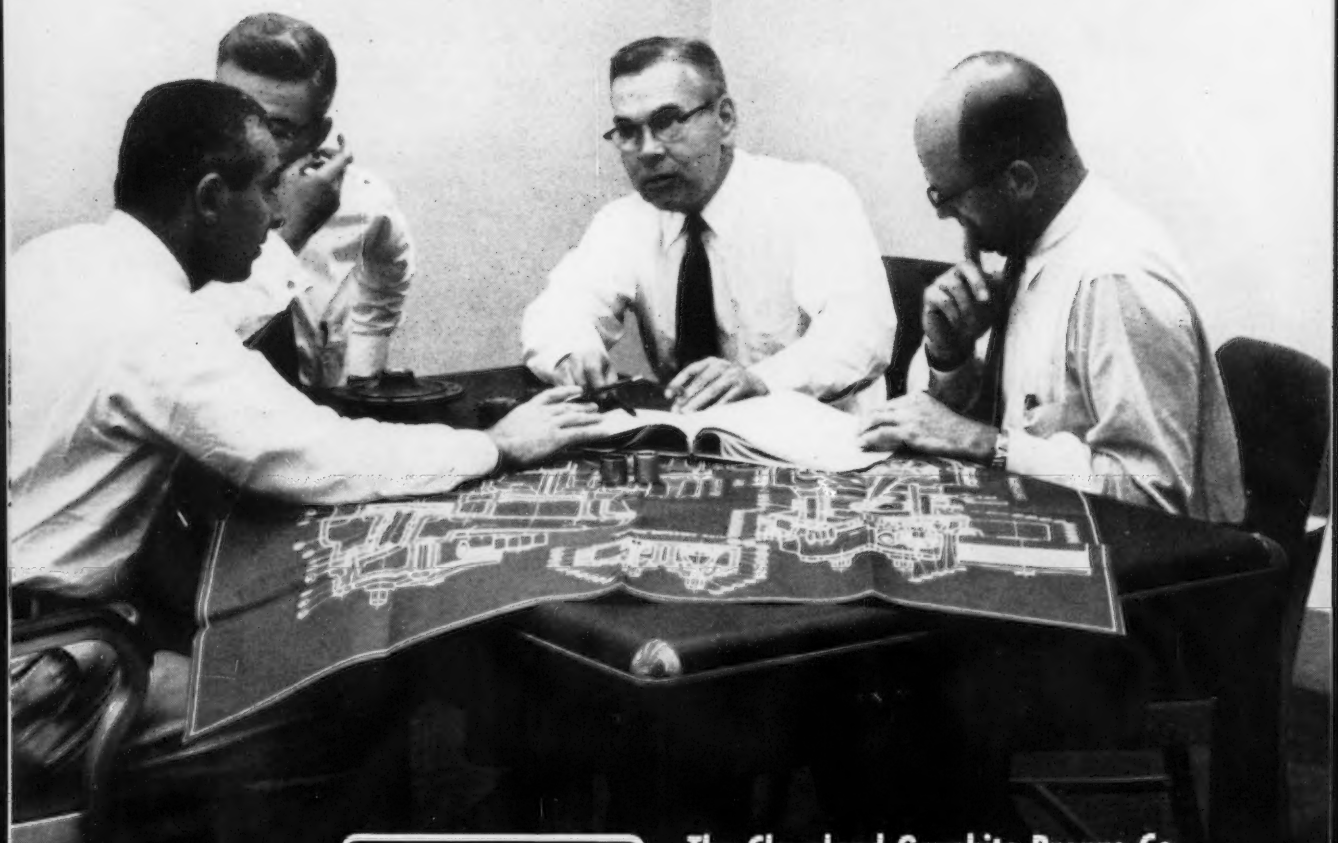
You get *something extra* when you call in Cleveland Graphite Bronze

Cleveland Graphite Bronze has become the leading maker of sleeve bearings and bushings because of the "extras" we give our customers.

One extra we give our customers is ***outstanding engineering:*** fundamental research at the Clevite Research Center; original thinking at the design stage; searching thoroughness in testing and development. To follow through, we have a fast, able team of field engineers, working on specialized problems in our customers' plants.

With this concentration on engineering, we have introduced almost all the real improvements in our industry in the past 35 years, and have put them to work for the leading manufacturers in half a dozen different fields.

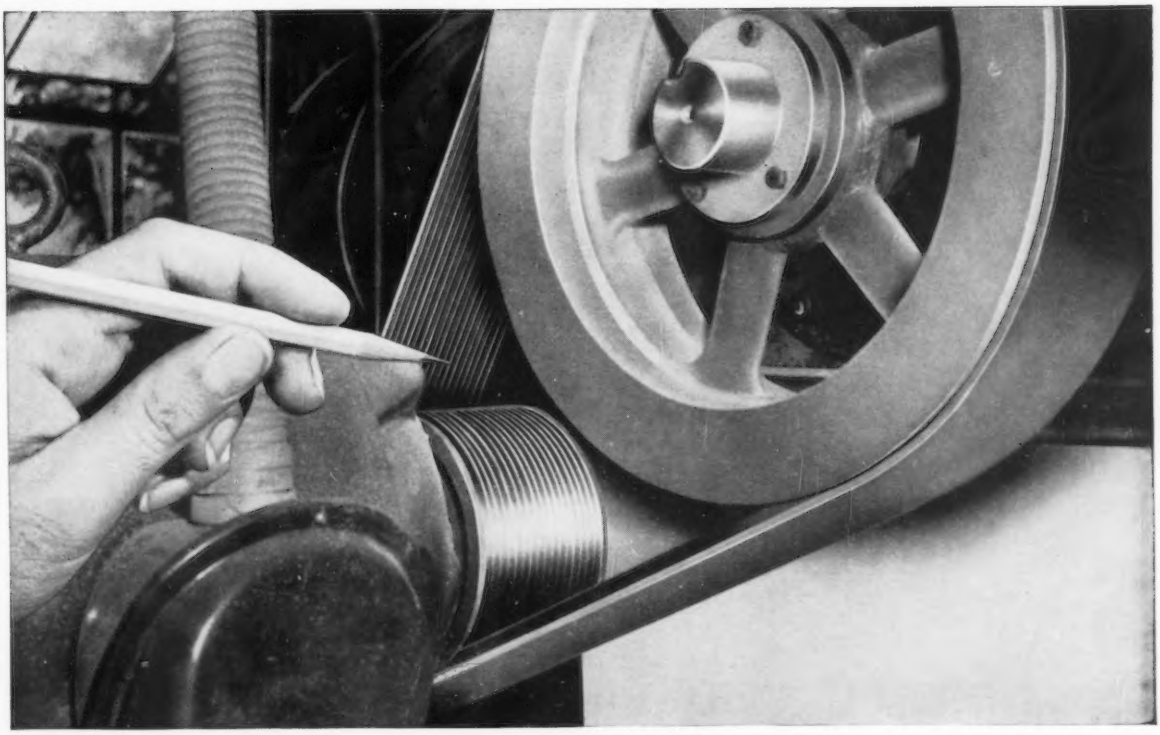
C. G. B. customers are getting the best advice, and getting it first. Are you missing out on it?



CLEVITE
CORPORATION

The Cleveland Graphite Bronze Co.

Sleeve bearings and bushings and other mass-precision metal parts



This Space Saving Drive Solves Difficult Design Problems . . New R/M *Poly-V® Drive*

Could greater power capacity in less drive space mean an improvement in your equipment drive design? It can be done with R/M Patented Poly-V* Drive . . . R/M's totally new concept in heavy-duty power transmission! Actual installations have proved that this belt drive can deliver up to 50% *more* power in the same space as ordinary multiple-belt drives . . . or *equal* power in as little as 2/3 the space!

The unusual space-saving advantages of R/M Poly-V Drive are the result of over 5 years development by R/M engineers. Employing a single, endless parallel V-ribbed belt running on sheaves designed to mate precisely with the belt ribs, gives Poly-V Drive the strength and simplicity of flat belts *plus* the high V-groove grip of V-belts. It means you get twice the tractive surface of multiple V-belts in the same drive width . . . twice the power capacity . . . "More Use per Dollar".

OTHER IMPORTANT ADVANTAGES INCLUDE:

- Single Unit Design — Eliminates Belt Matching Problems
- More Uniform Tension — Prolongs Belt and Sheave Life
- Two Belt Cross Sections — Meet Every Heavy Duty Power Transmission Requirement
- Oil Proof, Non Spark, Heat Resistant

Investigate R/M Poly-V Drive for the improved design of both new and existing equipment. R/M engineers will gladly work with you on power transmission drive problems. Contact an R/M representative.

CONDOR V-BELTS • R/M SUPER-POWER V-BELTS

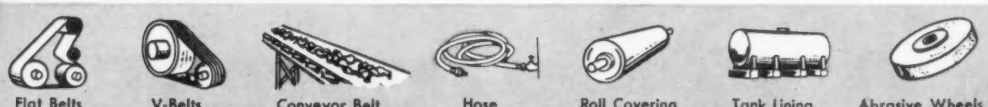
Write for Bulletin #6868 on the complete line of Condor V-Belts for regular service on conventional V-belt drives. Also write for Bulletin #6628 on R/M Super-Power V-Belts with 40% more Horsepower capacity where needed.

*Poly-V is a registered Raybestos-Manhattan Trademark

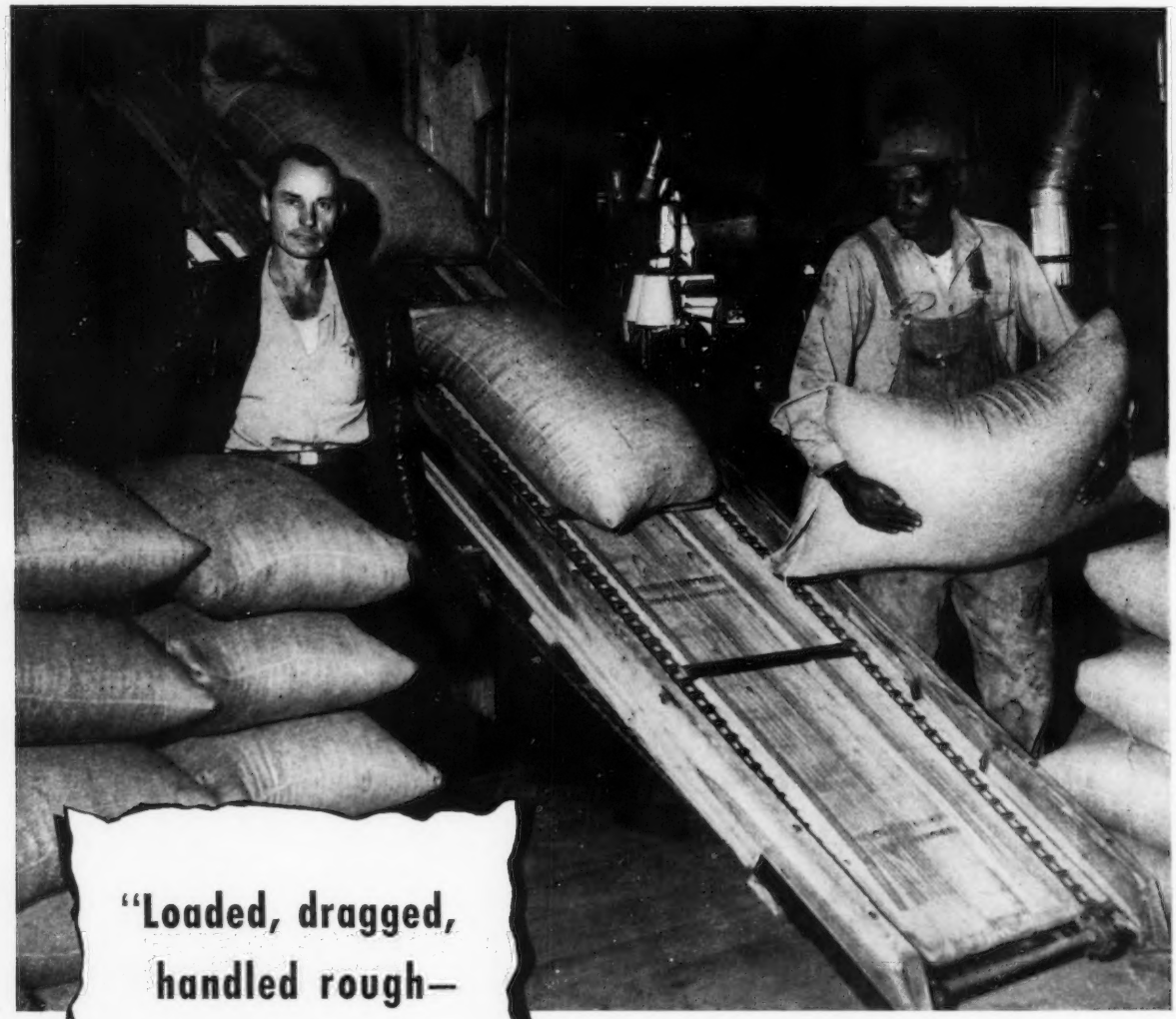
RM 627

MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.



Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Laundry Pads and Covers • Bowling Balls



"Loaded, dragged, handled rough—

burlap bags take a terrific beating," says Fred W. Schroer of Valdosta, Georgia. "We buy about 480 tons of fertilizer a year in burlap bags we don't have to coddle. They can absorb moisture if a sudden rain comes up, and good air circulation cuts down mold.

"We wash the bags right away and use them for everything on the farm. In our hopper for grain we can bag with burlap in record time. We ship seeds all over the country in burlap bags and know they'll reach their destination in good condition."

For supplies coming in, and produce going out — farmers like the "two-way" burlap bag.

FARM EXPERTS:

How many lives has a burlap bag?

About six. Farmers use them around the farm for hundreds of things—sell them for cash, or like Mr. Schroer, pack their own produce in them.

Burlap bags take rough handling and don't mind the weather. Help the farmers in your area to get their fertilizer, feed and other supplies in burlap bags. Write us for ammunition.

THE BURLAP COUNCIL
of the Indian Jute Mills Association
155 East 44th Street, New York 17, N. Y.

Ask the farmer's daughter...

she'll tell you why it's easier to sell a gasoline tractor.

There are lots of things that a farm family want to do for their daughter. She needs money for new clothes, entertainment and education. Each takes a bite out of the farmer's yearly income.

So when you're trying to make a tractor sale, consider the farmer's budget as closely as he does. Let the lower initial cost of a gasoline tractor be your big selling point. The farmer knows that savings on equipment allow him more money for his family's needs.

The difference in price is only one of the many selling advantages today's gasoline tractors offer. Now high compression engines deliver up to 30% more power . . . give greater all-round convenience. And gasoline tractors require less maintenance . . . have a greater trade-in value even after years of service.

Next time a farmer walks into your showroom . . . remember the farmer's daughter. You'll be on your way to a gasoline-tractor sale.

ETHYL CORPORATION

NEW YORK 17, N. Y.

New Products and Catalogs

(Continued from page 354)

Two-Row Cotton Pickers

International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill., has announced production of two new 2-row mechanical cotton pickers. Both new pickers are self-propelled and readily adapted for work on farms or ranches of medium to big acreage operations.

The No. 220 picker is equipped with high drums, for use in tall, heavy, and higher yielding cotton. The other new model is the No. 214, equipped with low drums for use in short to medium height plants. Both models are identical except

for the height of the picking units. The machines have short wheelbases and a turning radius of about 10 ft. Picking units can be adjusted for rows 38 to 40 in wide, and the operator sits over the left row where he has a full-vision view.

The new pickers are powered by 68-hp engines and are equipped with a 3-speed transmission to provide two speeds for picking and one for transport on the road. The field speed of 2 mph is generally used the first time through heavy cotton. The second field speed of 2.8 mph is used for scrapping or when picking lighter yields. Transport speed is 13 mph. The 1600-lb cotton basket is hydraulically operated.

Wind Machines For Frost Protection

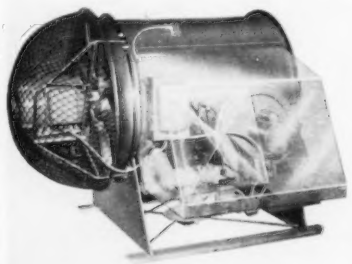
National Frost Protection Co., Glendale, Calif., has developed a wind machine for citrus growers to combat crop losses due to annual freezes. The manufacturer reports that a dual wind machine, like the model shown, can protect up to 20 acres in citrus, or up to 30 acres in deciduous orchards. The 30-ft high platform rotates once every 9 min as the 12-ft propellers rotate about 880 rpm to move air at 630,000 cfm. A 600-gal gasoline storage tank is contained inside the tower. The machine is operated and controlled entirely from the ground.

New Gas-Fired Crop Drier

The Hartzell Propeller Fan Co., Agricultural Div., Piqua, Ohio, has announced a new gas-fired crop drier designed to fit into most any drying system.

The drier is furnished skid-mounted or with mounting brackets for use with a batch drying bin. The skid-mounted model, with the heated air carried by a canvas duct, dries grain in wagon bed or storage bin, hay in the mow or even lumber. It can also be used for heating brooder house, shops and other farm buildings.

As an extra safety feature the main gas line closes automatically in the event of



power failure, flame failure at the main burner or excessive outlet temperature. In any of these cases, the unit will not operate again until it has been manually reset. One hand-operated valve controls the firing rate which may be set at any point between maximum (1,000,000 Btu per hr) and minimum (400,000 Btu per hr). The drier burns either LP or natural gas.

The fan is an 8-blade high-pressure design, 36 in in diameter. The aluminum alloy propeller is driven by either a 5 or 7½-hp motor.

(Continued on page 366)

The tiny ant has strength and stamina far out of proportion to its size...

HEAVY-DUTY POWER CAN BE PACKED INTO SMALL SPACE, TOO!

WISCONSIN

HEAVY-DUTY *Air-Cooled* ENGINES

Shown here is the largest engine in the Wisconsin line... the 36 hp. Model VG4D. This compact, heavy-duty power package has incorporated in its design and construction all the heavy-duty features that make it comparable in rugged stamina and performance dependability to heavy-duty engines of much greater size.

The 11 other models, ranging from the 2.3 to 5.6 hp. Model ACN 4-cycle single cylinder engine, to the Model VF4, 25 hp. V-type 4-cylinder are similarly so compactly power-packaged that these engines can be fitted to *your* equipment with a minimum of re-designing — backed by authorized service throughout the world.

Complete specifications and engineering data gladly supplied. Write today for Bulletin S-188.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

PEORIA MALLEABLE CASTINGS

ARE

PART OF

THE

ALLIS-CHALMERS

PICTURE

Allis-Chalmers – a famous name in farm equipment, tractors and earthmoving equipment – is another in the list of leading manufacturers who use Peoria Malleable castings in their products.

Peoria Malleable castings have earned the confidence placed in them. They are quality parts – long lasting and good looking. And very often they cost less than the material and labor involved in manufacturing a part as a weldment or a forging.

Send a letter for further information – or send specifications for a definite quotation, at no obligation.

A big part of **QUALITY** *is a* **QUALITY** *part*

STANDARD OR PEARLITIC

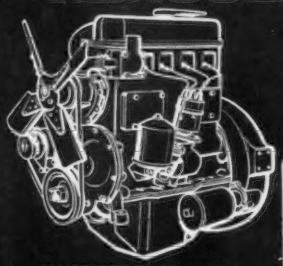
PEORIA MALLEABLE CASTINGS CO.

FT. OF ALEXANDER ST., PEORIA, ILLINOIS

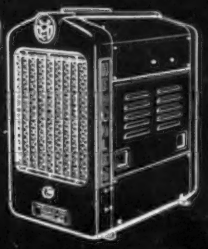
FAMOUS FOR **QUALITY**

Allis-Chalmers HD-9 diesel crawler tractor cultivates ground with Allis-Chalmers 5-point chisel attachment for the Oxnard-built tool-bar carrier.

HERCULES ENGINES . . .

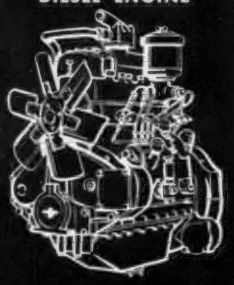


OVERHEAD VALVE GASOLINE ENGINE



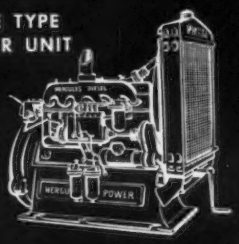
CLOSED TYPE POWER UNIT

TURBULENCE CHAMBER DIESEL ENGINE

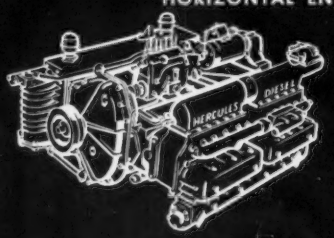


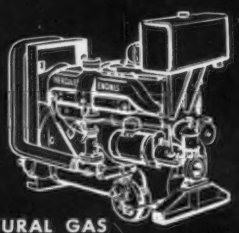
The complete line of engines and power units from 3 to 500 H. P.

BASE TYPE POWER UNIT

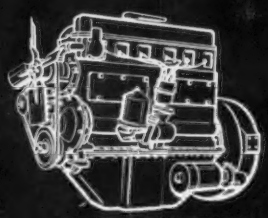


"PANCAKE" or HORIZONTAL ENGINE





NATURAL GAS L-HEAD ENGINE



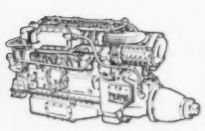
DIRECT INJECTION DIESEL ENGINE

The wide selection of engine types and sizes in the Hercules line, plus the flexibility of our production facilities provide a complete line of dependable power to meet the varied needs of many different industries.

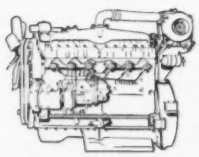
In addition to the various types of engines and power units illustrated, it is the policy of Hercules Motors Corporation to engineer and produce these engines to the specific requirements of each industry.

For assistance in solving your particular power problems, contact Hercules Motors Corporation—Engine Manufacturing Specialists since 1915.

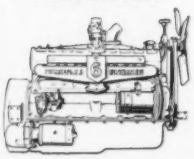
MARINE DIESEL



TURBO-CHARGED DIESEL



L-HEAD GASOLINE



HERCULES MOTORS CORPORATION
CANTON 2, OHIO

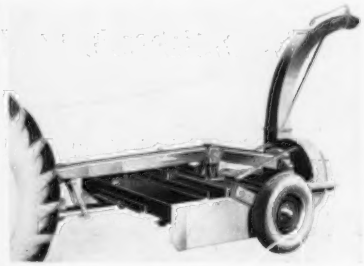
New Products and Catalogs

(Continued from page 364)

New Shredder-Harvester

Brillion Iron Works, Brillion, Wis., has introduced a new shredder-harvester that combines the features of a rotary shredder with a newly designed blower.

The new shredder-harvester is built to cut, gather and load grass for bunk feeding, combined grain straw and picked corn stalks for bedding. With the blower unit



disengaged the rotary shredder will handle any type of shredding from cornstalks and pasture clippings to heavy brush and orchard prunings.

The rotary shredder features pto drive with three needle-bearing universal joints and a slip-clutch blade control. The blower features a 30-in-diameter fan which attaches to the shredder housing and drives off the power take-off. Protection against overload on the blower assembly is provided by a universal shear joint. The blower is designed for attachment on all Brillion rotary shredders.

New Roller Bearing Booklet

Link-Belt Co., Dept. PR, Prudential Plaza, Chicago, Ill. will send upon request a new 8-page book, No. 2658. This book describes series S, adjustable single-row self-aligning roller bearings; series D, adjustable double-row bearings, and series M, pre-adjusted double-row self-aligning bearings. It also gives engineering selection information, complete dimensional specifications and recommended fitting practices.

Power Steering for Tractor

International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill., has announced that power steering is available for the McCormick Farmall 300, 400, and the high-

clearance versions of these tractors. The principal part of the power steering attachment consists of a hydraulic power booster installed on the steering shaft under the hood. This booster is a small hydraulic motor that operates the steering mechanism. The motor gets its power from the hydraulic system of the tractor. As the steering wheel is turned, valves divert oil to the proper side of the gears in the booster, causing it to function and turn the front wheels.

(Continued on page 368)

The Oliver Model 50 Twine-Tie Baler

Simple design pays off in the bale

This is a time when dollars count. Nowhere do they count more heavily than in the farmer's baling operation—where all depends on getting that perishable crop in fast. A new baler is his best insurance of haying profits. Best of all, an Oliver; then the payoff is doubly sure.

Take this Oliver Model 50 Twine-Tie Baler. See how simply it's designed? You have only to look at a bale to see where that simple design pays off.

Notice the quality. This hay was baled at just the proper stage. The instant the crop is "right," the Model 50 moves fast and keeps moving. A sturdy machine which has fewer parts to go wrong.

Notice the leaves. They're there, *in the bale*—the valuable proteins with them. That's because the Model 50 takes the hay from windrow to bale with an absolute minimum of handling. Up...across... out. Again, *simple design.*

And capacity! Simple design means that all weight is *working* weight—the Model 50 bales up to nine tons an hour. (And how effortlessly when attached to an Oliver Tractor's Independently Controlled PTO!)

Cut the twine, and see just what kind of bale this machine turns out. See how the bale opens? All in separate, even slices—just right for feeding.

Look at it any way you will, *this simpler design pays off for the farmer.*

The Oliver Corporation
400 West Madison St.
Chicago 6, Illinois

OLIVER

WHITNEY SELF-LUBRICATING AGRICULTURAL CHAIN SETS NEW PERFORMANCE STANDARDS . . .

Now you can equip all farm machinery using conveyor or transmission type roller chain with Whitney's revolutionary *Self-Lubricating* Chain . . . the agricultural chain that assures lower maintenance and longer life.

WHY Stud Bushings In Whitney Agricultural Chain?
By replacing conventional chain rollers with sintered stud bushings, Whitney Agricultural Chain provides additional lubricant storage area for prolonged self-lubricating service.

Whitney *Self-Lubricating* Agricultural Chain has high strength, pre-lubricated sintered steel bushings that oil from the *inside*. The tougher the usage, the more lubrication to vital chain points. *Self-Lubricating* Chain is self-cleaning . . . has controlled plate clearance to eliminate "freezing."

Whitney *Self-Lubricating* Agricultural Chain, made of premium materials is engineered for all types of farm machinery. They are completely interchangeable and interlace with A.S.A. double pitch chain.

ANOTHER example of Whitney leadership. Whitney will gladly assist in determining the chain best suited to your requirements.

For full information, write —

Whitney
CHAIN COMPANY
246 HAMILTON STREET, HARTFORD 2, CONNECTICUT

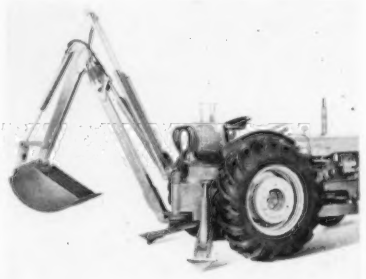
New Products and Catalogs

(Continued from page 366)

Power Digger

Sherman Products, Inc., Royal Oak, Mich., has introduced a new hydraulic backhoe specifically designed and built for attachment to Fordson-Major tractors. The all-new digger reaches as deep as 12½ ft. With a 180-deg arc of swing it can clear a height of 8 ft, 8 in for loading trucks.

Features include twin crowd cylinders, steel plate digger construction, large diam-



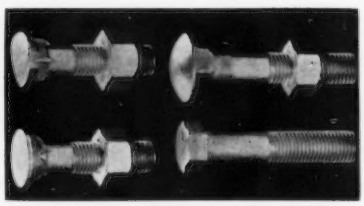
eter hinge pins, replaceable hardened steel bushings and heavy-duty steel castings.

A new bucket linkage provides maximum wrap-around and also a stroke up to 5,000-lb effective pressure, throughout bucket travel. Steel-cable linkage between two opposing, long-stroke, double-acting hydraulic cylinders provides control of swing action.

Cadmium-Plated Bolts

Clark Bros. Bolt Co., Milldale, Conn., has introduced a line of cadmium-plated bolts for repair and replacement use on a variety of tractor-drawn implements.

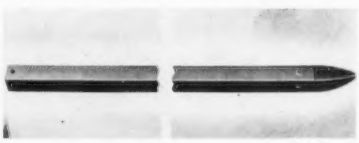
The new bolts are manufactured to precise dimensions, and are available in a



wide variety of head styles, lengths and diameters to meet virtually every need. They have standard fine (SAE) threads and are cadmium-plated as a protection against rusting.

Sled-Design Stacker Teeth

Dultmeier Mfgr. Co., Manning, Iowa, has announced production of new steel teeth for sweeps and stackers. The new teeth have a special sled-design point designed to pre-



vent digging in. Special flexible tubing gives strength and stability. The teeth are designed to be installed on any sweep or stacker. A special clamp is also available for those who wish to install steel teeth by this method instead of using bolts.

(Continued on page 370)

Here are the
NEW GRADE NAMES
for West Coast Lumber

...the ideal farm building material

Save money! Recommend the right grades of West Coast lumber for all farm building needs. Ask for them by name.

CONSTRUCTION . . .
(Formerly No. 1)
Recommended for sound, dependable construction of all kinds.

MILL 750 WC LB CONST

STANDARD . . . . . .
(Formerly No. 2)
Usually used in conjunction with "Construction" grade for all building purposes.

MILL 750 WC LB STAND

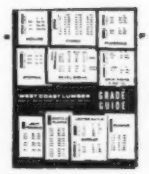
UTILITY. . . . . .
(Formerly No. 3)
A serviceable grade for use where appearance is not of primary importance.

MILL 750 WC LB UTIL

ECONOMY. . . . . .
(Formerly No. 4)
Lumber of this grade is suitable for crating, bracing and temporary construction. Pieces of higher grade may be obtained by cutting.

MILL 750 WC LB ECON

FOR ADDITIONAL INFORMATION SEND FOR FREE FOLDER, "Grade Guide". Describes uses and shows grade stamps for all new grades.



For ALL your building needs

WEST COAST LUMBER

Douglas Fir • West Coast Hemlock
Western Red Cedar • Sitka Spruce

WEST COAST LUMBERMEN'S ASSOCIATION
1410 S. W. Morrison, Box 4, Portland 5, Oregon

Please send me your FREE folder "Grade Guide".

Name _____

Address _____

City _____

State _____

New Products and Catalogs

(Continued from page 368)

Farm Concrete Manual

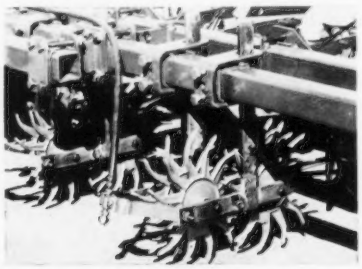
Wire Reinforcement Institute, Dept. FC, National Press Bldg., Washington 4, D. C., has released a new illustrated, 28-page design manual on reinforced concrete construction for the farm.

The manual discusses reinforced concrete construction and points out the specific applications of welded-wire fabric reinforcement to many farm structures. Principal topics covered are dairy and cattle barns, feeding floors and paved yards, concrete silos, septic tanks and soil conservation structures.

Copies may be obtained without charge by writing to the Wire Reinforcement Institute. Farm organizations, clubs, and agricultural schools will be furnished the booklet in reasonable quantities.

Develops Spray Tiller

Howry-Berg Steel and Iron Works, Inc., 1366 W. Oxford, Englewood, Colo., has announced the development of a spray-tiller, a new chemical applicator which combines



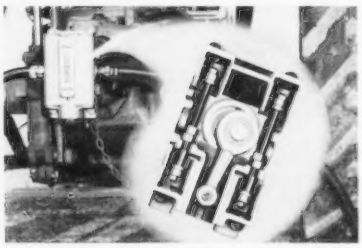
spraying, mixing and tilling into a single operation. Mounted in front of the planter, the new tool applies chemicals in a band directly over the rows. The tillers, set behind the spray nozzles, mix the chemicals into the soil ahead of the planters. If desired, the spray-tiller may be used alone as a crust breaker. The unit is fully adjustable, both as to width of row and depth of chemical application—from ½ to 4 in. It is easy to install on most types of planters and can be obtained for any number of rows desired.

New Quonset Booklets

Stran-Steel Corp., unit of National Steel Corp., Ecorse, Detroit 29, Mich., has released three new booklets describing the company's line of farm buildings. The first is a color folder explaining the action taken by an Ohio farmer in replacing his farm buildings after a major farm fire. The second is a 2-color folder entitled, "Don't Let Spoiled Grain Spoil Your Profits," and describes available Quonset grain-drying systems. The third is a comic book entitled, "The Story of Quonset."

Four-Piston PTO Sprayer Pump

Hanson Equipment Co., Beloit, Wis., has developed the new Model FP, 4-piston, self-lubricating, sprayer pump. The new self-lubricating feature is said to eliminate pump damage due to contamination or dilu-



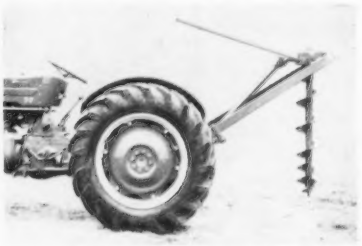
tion of oil by spray solutions. The pump is designed to handle all types of spray materials, including wettable powders.

The four pistons of the pump are opposed in pairs at 180 deg. Pump capacity is 9.4 gpm at any desired pressure up to 400 psi. Hardchromed cylinder-wall sleeves are replaceable. Wear-compensating piston cups are said to keep uniform and constant pressure against the cylinder walls.

The pump measures 5½x5½x10 in and weighs 28 lb. It mounts directly on the pto shaft of any tractor or can be base-mounted for belt-driven or direct-drive installations.

Posthole Digger

J. & S. Foundry, Inc., Dewey, Okla., has announced production of the Mark II posthole digger unit, designed to attach to most leading brands of tractors. Features include



ductile-iron gears and wearing parts, a strong U-beam A frame, Timken bearings, Blood Brothers drive with adjustable length drive-shaft, and a thrust-spacer which is said to eliminate vertical thrust on gear teeth through use of a spacer separated from the gear and pinned separately to the auger shaft. A safety torque clutch, a safety shield for drive-shaft and a two-point-hitch attachment for use with some tractors are optional.

ROCKFORD

FIRST

Using a new type friction material of recent development, ROCKFORD was the FIRST to engineer these new materials into MORLIFE Clutches and Clutch Plates. They reduce clutch size and engaging pressure, operate longer without adjustment or plate replacement — and avoid down-time caused by burned or warped plates in heavy duty tractors, trucks, tanks, cranes, power units, shovels, bulldozers, earth movers and other heavy duty machines.

MORLIFE* CLUTCHES and CLUTCH PLATES

*TRADE MARK

"MORLIFE clutch has gone 851 hours without slipping or adjustment."

"MORLIFE clutches last 950 hours longer, without adjustment."

"MORLIFE clutch needs adjustment once a month, instead of daily."

"MORLIFE requires lighter handle pull and one tenth the adjustments."

"MORLIFE clutch going strong after 1695 hours, working in sand."

"MORLIFE pulls harder and lasts six to ten times longer."

400% MORE LIFE

100% MORE TORQUE

50% MORE HEAT RESISTANCE

Before you approve specifications for your next models, it will pay you to investigate how MORLIFE Clutches will add to the service life of your product and reduce the number of stops for adjustments and repairs. It also will pay you to recheck specifications for your present models. For information covering operating characteristics, write Department E.

ROCKFORD Clutch Division BORG-WARNER

1325 Eighteenth Avenue, Rockford, Illinois, U.S.A.

CLUTCHES

Know How and RESPONSIBILITY are behind "WHEELS by F&H

Our constant search for wheel improvement takes ALL factors into account—

- The design of WHEELS and HUBS
- The design of SPINDLES and AXLES
- Selection of adequate anti-friction BEARINGS
- Selection of suitable closure SEALS
- Selection of types and sizes of rubber TIRES

INTEGRATED ENGINEERING — F&H — Since 1888

May we assist you in cost reduction through our **PACKAGE PLAN?**

FRENCH & HECHT
DIVISION
KELSEY · HAYES WHEEL COMPANY
DAVENPORT, IOWA

Who Should Join ASAE

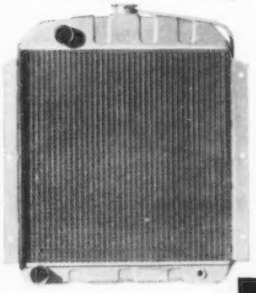
If any one of the following descriptions covers your present work:

- Development, design, and application of farm tractors and implements and their components
- Design and improvement of farm buildings
- Engineered improvements for soil and water conservation and use
- Creating applications for electricity in farm practice and living—

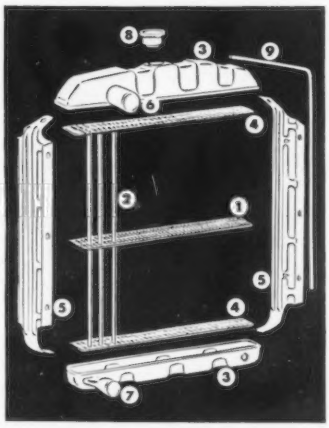
then you can derive much benefit from membership in ASAE, and the Society cordially invites you to make application. For further information write

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS
St. Joseph, Michigan

Pressed Tank *Radiator* designed by Young offers



More Strength!
Less Weight!
Better Performance!



1. Fin design gives sufficient air turbulence for maximum heat transfer.
2. Double lockseam tube provides strong backbone for entire core.
3. Die-formed header, reinforced 1-piece, heavy duty brass top and bottom tanks.
4. Leakproof assembly with double-grip, 2-way header with lapped joint solder sweated to tanks.
5. Full wrap around type terne plate side members secure tanks, headers and core as one piece.
6. Fabricated brass inlet and (7) outlet. Maximum flow area, minimum resistance to coolant circulation.
8. Neck for pressure type cap. Safe; no water loss from after-boil.
9. Overflow tube.

YOUNG Radiators are used wherever the going is tough. Creative engineering and exclusive features insure unbeatable performance from Young-quality radiators. Their dependability and efficient cooling has been field proven in automobiles, tractors, trucks, busses and other mobile and stationary engines. The three-way team of Young *research*, Young *engineering* and Young *production* is responsible for the high reputation of Young radiators in the automotive field.

Write Dept. 296-E for FREE Catalog

Put *Young Talent* to work for you . . .

Solving heat transfer problems is what we do best because it is our very reason for being. You, too, can harness the power of Young engineering talent. Write, wire or call without obligation.

Young RADIATOR COMPANY
RACINE, WISCONSIN
Creative HEAT TRANSFER ENGINEERS FOR INDUSTRY
Heat Transfer Products for Automotive, Aviation and Industrial Applications. Heating, Cooling, Air Conditioning Products for Home and Industry.
Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

New Products and Catalogs

(Continued from page 370)

New Tractor Models

Tractor and Implement Division, Ford Motor Co., Birmingham, Mich., has announced that the Fordson Major Diesel tractor now is available in two tricycle

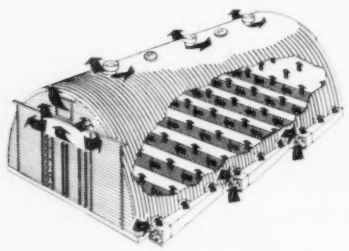
models. Two models of four-wheel utility FMD tractors are also announced for applications where hydraulic lift and implement linkages are not required.

The two tricycle front end models are the FMD-72, with rear wheel tread adjustments of 52 to 72 in, and the FMD-96, with rear axle extensions for tread adjustment from 56 to 96 in. The two utility models are the FMD-U12, equipped with 12-in rear tires, and the FMD-U14, with 14-in rear tires.

All models are equipped with spur gear transmissions with six forward and two reverse speeds; sealed beam headlights and taillight; adjustable swinging drawbar; 12-volt electric system and starter motor; oil bath air cleaner; transmission type power take-off, 600-lb wheel weights; and an all-in-one instrument that indicates engine rpm, total hours of engine operation, and ground, pto and belt pulley speeds.

New Drier-Storage Unit

Stran-Steel Corp., Unit of National Steel Corp., Ecorse, Detroit 29, Mich., has introduced a new Quonset grain-drier-storage unit using unheated air to supplement new



early-harvest methods. The new drier-building reportedly cools as well as stores the grain after it has been dried, and permits the farmer to dry and store his whole crop with only one handling. The manufacturer reports that by enabling early harvest at a high moisture-content, the new system reduces field-losses, saves labor, and eliminates heat-damage or loss in germination. After the grain is dried, reversing the drying fans cools and stores it with little damage of spoilage. The systems are available in 2,000 to 40,000-bu capacities.

Plumbing and Hydrant Catalog

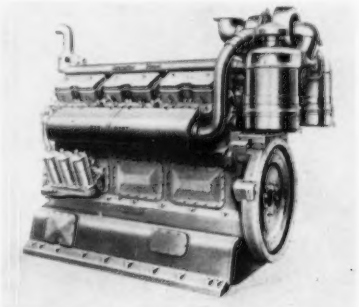
Ken-Ray Brass Corp., Vermont, Ill., has released a new 8-page plumbing accessories catalog describing a complete line of faucets, hydrants, gas cocks, valves and fittings.

In two-colors, the new literature outlines special features of the non-freezing wall faucet, the ground hydrant and the wall hydrant. Dimensions and specifications of these units appear in tabular form accompanied by a cross-sectional blueprint.

New V-Type Engines

Caterpillar Tractor Co., Peoria, Ill., has introduced two new heavy-duty V-type engines designed to produce up to 650 hp (maximum). The new 8 and 12-cylinder D375 (Series D) and D397 (Series D) engines are of four-cycle design, as were their predecessors, the D364, D375, D386 and D397.

Principal differences between the new engines and the former models are in the cylinder heads, exhaust manifolds, method of supercharging, and a new method of igniting fuel in the case of the spark-ignited engines.



The new turbochargers are designed to utilize energy of exhaust gases which would otherwise be wasted. The new cylinder heads provide a more direct path from the combustion chamber to the exhaust manifold. New exhaust manifolds are offered in dry, shielded and wet versions. The new shielded manifolds utilize heavy layers of fiber glass, encased in steel, to keep heat out of the engine.

The new spark ignited engines feature a 10 to 1 compression ratio, a low-tension magneto ignition system and deep-domed pistons. The new ignition system uses a magneto to feed low-tension current to high-tension transformers located near the spark plugs.

Model D397 (illustrated) is rated at 400 hp for the spark-ignited engine and up to 650 maximum hp for the turbocharged version. The D375 is rated at 267 hp and 430 maximum hp for the respective versions.

Bearing Catalog

Chain Belt Co., Milwaukee 1, Wis., has released a new 72-page catalog on Shafer self-aligning roller bearings. The new catalog contains specification and data pages on all models of Shafer units. These various models have shaft sizes which range from ¾ to 7 in. Included in the catalog is completely revised engineering data, new load rating tables and exploded views for parts identification.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Beitel, Howard V.—Draftsman, product development dept., Deere & Co., Moline, Illinois

Byers, Gordon L. — Associate professor of agricultural engineering, University of New Hampshire, Durham, N. H.

Clum, Chester B.—Sales engineer, Detroit Diesel Engine Div., General Motors Corp., Detroit, Mich.

Drayer, Ted G.—Design engineer, International Harvester Co., East Moline, Ill., (Mail) 507—28th Ave., Moline

Enslin, Douglas D. — Production trainee, Ralston Purina Co., (Mail) 41 Main St., St. Johnsbury, Vermont

Koopman, C. Jan—Agronomist, FAO Mission, UNTAB, P.O. Box 1555, Teheran, Iran

Myers, Lloyd E., Jr. — Irrigation engineer, Western Soil and Water Management Section, ARS, USDA (Mail) Hatch Building, University of Nevada, Reno, Nevada

Neves, Arthur A. — Agricultural engineer, Escola Superior De Agricultura "Luiz De Queiroz," University of Sao Paulo, Piracicaba, Brazil

Pfister, Richard G.—Extension agricultural engineer, Michigan State University, East Lansing, Michigan

Reece, Carroll K. — Instructor, Kansas State College (Mail) 1823 Hunting, Manhattan, Kansas

Riddle, Raymond R.—Owner, New England Rototiller Sales, Palmer, Mass.

Robinson, August R., Jr.—Agricultural engineer, Colorado A & M College, Ft. Collins, Colo.

Ruffner, John M.—Regional field engineer, Fenwal, Inc., 6525 W. North Ave., Oak Park, Ill.

Russell, Wayne G. — Rural sales assistant, Wisconsin Power & Light Co., 122 W. Washington Ave., Madison, Wisconsin

Schroeder, Richard A.—Farm machinery advisor, International Cooperation Administration (Mail) American Embassy, Karachi, Pakistan

Shipe, Paul T.—Platoon leader, U.S. Army, Fort Knox, Kentucky. (Mail) Blaine, Tennessee

Snow, Russell T. — Agricultural engineer, Soil Conservation Service, USDA, 24½ East Huron St., Pontaic, Michigan

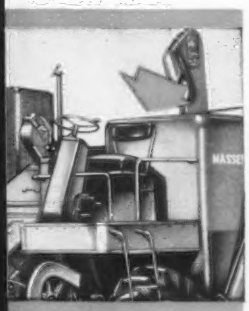
Sullivan, James M.—Project engineer, New Departure Division, General Motors Corp., Bristol, Connecticut

Transfer of Membership

Bond, Ned J., Jr.—General superintendent, Louisiana State Rice Milling Co., Abbeville, La. (Associate Member to Member)

Daniels, Stephen A.—Agricultural engineer, Soil Conservation Service, USDA, Carrollton, Ga. (Mail) Box 192, Mt. Zion, Ga. (Affiliate to Associate Member)

Klein, R. W.—Assistant professor of agricultural engineering, University of Illinois, Urbana, Ill. (Associate Member to Member)



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PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—1955—AUGUST—O-324-745, 334-746, 338-747, 346-749, 346-750, 347-751, 350-752. SEPTEMBER — O-331-754, 335-756, 352-758, 372-759. OCTOBER—O-402-762, 405-765, 409-766, 409-767, 409-768, 407-769, 407-770, 413-772, 415-773. NOVEMBER—O-385-775, 430-776, 451-779, 453-780, 453-781, 454-782, 448-783, 463-784, 463-785. DECEMBER—O-476-786, 503-787. 1956 — JANUARY — O-455-789, 534-790, 537-791. FEBRUARY—O-4-601, 4-602, 6-603, 12-604, 15-605, 29-606, 22-607. MARCH—O-60-608, 60-609, 71-611, 80-612. APRIL—O-105-613, 115-614, 117-615, 117-616, 119-617, 127-618, 136-619.

POSITIONS WANTED — 1955 — SEPTEMBER — W-351-41. OCTOBER—W-383-43, 398-45. NOVEMBER—W-429-51, 445- 52, 450-53. DECEMBER—W-458-56, 486-57, 489-58, 480-59. 1956—JANUARY—W-457-60, 528-61, 529-62. FEBRUARY—W-8-1, 18-5, 30-6, 37-7. MARCH—W-67-9, 55-10. APRIL—W-50-11, 101-12, 90-13, 96-14, 43-15, 53-16.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER to design farm buildings and facilities for agricultural experiment stations in a north central state, as a member of the staff of the physical plant department of the state university. Age 24-50. BS degree in agricultural engineering, or equivalent, with major or keen interest in farm structures. Experience in design of animal shelters and crop storages highly desirable. Interest in agriculture and ability to work with other engineers, as well as with those supervising the use of buildings. Normal opportunity for advancement. Salary open, depending on experience and ability. O-133-620

AGRICULTURAL ENGINEER for design and development work on light excavating equipment attachments for wheel-type tractors, with established western manufacturer. Age 25-45. BS deg in agricultural or mechanical engineering preferred, or design experience on material handling and related equipment. Good personality, ability to cooperate and get along with others, initiative and imagination to develop outstanding equipment. Opportunity to handle all phases of design, development and experimentation through final acceptance for production. Salary $4500-5000. O-155-621

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for sales, service or management in soil and water field, with consultant, farming operation or trade association, preferably in Pacific Northwest or West. Moderate travel. Single. Age 27. No disability. BS deg in agricultural engineering, 1950, Oregon State College. Farm background. Experience in seed company warehouse before graduation. With SCS since 1950, except 2-year war enlisted service in Navy, in electrical work. Registered professional engineer. Licensed private pilot. Available in 60 days notice. Salary open. W-125-17

AGRICULTURAL ENGINEER for sales, service or management in farm structures field with manufacturer, distributor, farming operation or trade association in East. Willing to travel. Married. Age 31. No disability. BS deg in agricultural engineering, 1949, Pennsylvania State University. Retail lumber sales 1½ yr. War service as naval aviation cadet. Available now. Salary $5500-6000. W-139-18

AGRICULTURAL ENGINEER for teaching, sales, service or writing in power and machinery field, with manufacturer, distributor, or farming operation in Midwest or East. Married. Age 38. No disability; BS deg in agriculture, Uppsala, Sweden, 1946. MS deg in agricultural engineering, Iowa State College, 1948. Farm background. Teaching farm power 2 yr. Testing farm machinery 2 yr. Technical Assistant to sales director, 2 yr. Normal service in Swedish Air Force. Available in fall of 1956. Salary open. W-143-19

ASAE Annual Meeting Program

(Continued from page 348)

be conducted on the subject of zero pastures. The final paper on the morning program is on potentiality of new strains of forage crops by H. R. Fortmann, Pennsylvania State University.

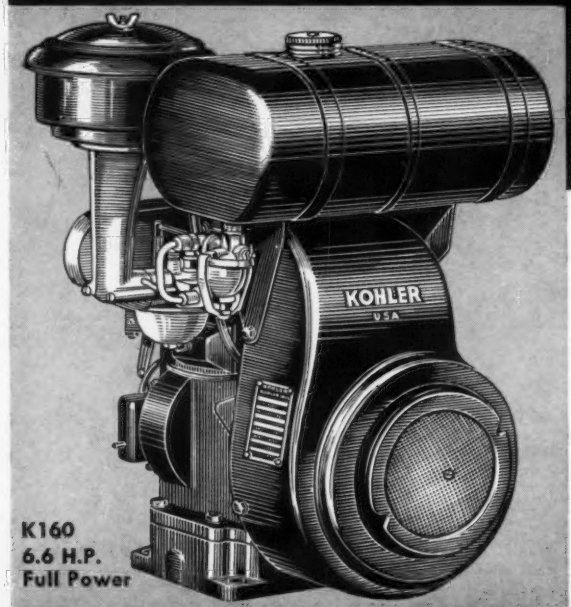
On Wednesday afternoon, the National Joint Committee on Grassland Farming will hold a joint session with the Power and Machinery Division. See the Power and Machinery Program for details. On Thursday forenoon, a field trip to areas of interest to grassland farming is planned. Busses will be provided.

OTHER PROGRAM ATTRACTIONS

In addition to the programs being arranged by the regular ASAE Divisions, several concurrent programs and group meetings are being scheduled. The Committee on Agricultural Teacher Training will meet on Saturday and Sunday, June 16 and 17. The following group meetings are planned for Tuesday morning, June 19: Extension Agricultural Engineers, 7:00 a.m., for breakfast; Committee on Soil Compaction at 8:00 a.m.; Committee on Instrumentation and Controls at 8:00 a.m.; and Committee on Extension at 8:30 a.m.

STUDENT PROGRAM

An interesting program is being arranged for students enrolled in agricultural engineering curriculums or those just graduating from state agricultural colleges and universities. This program is under the joint sponsorship of the officers of the National Council of ASAE Student Branches and the ASAE Committee on Student Branches.



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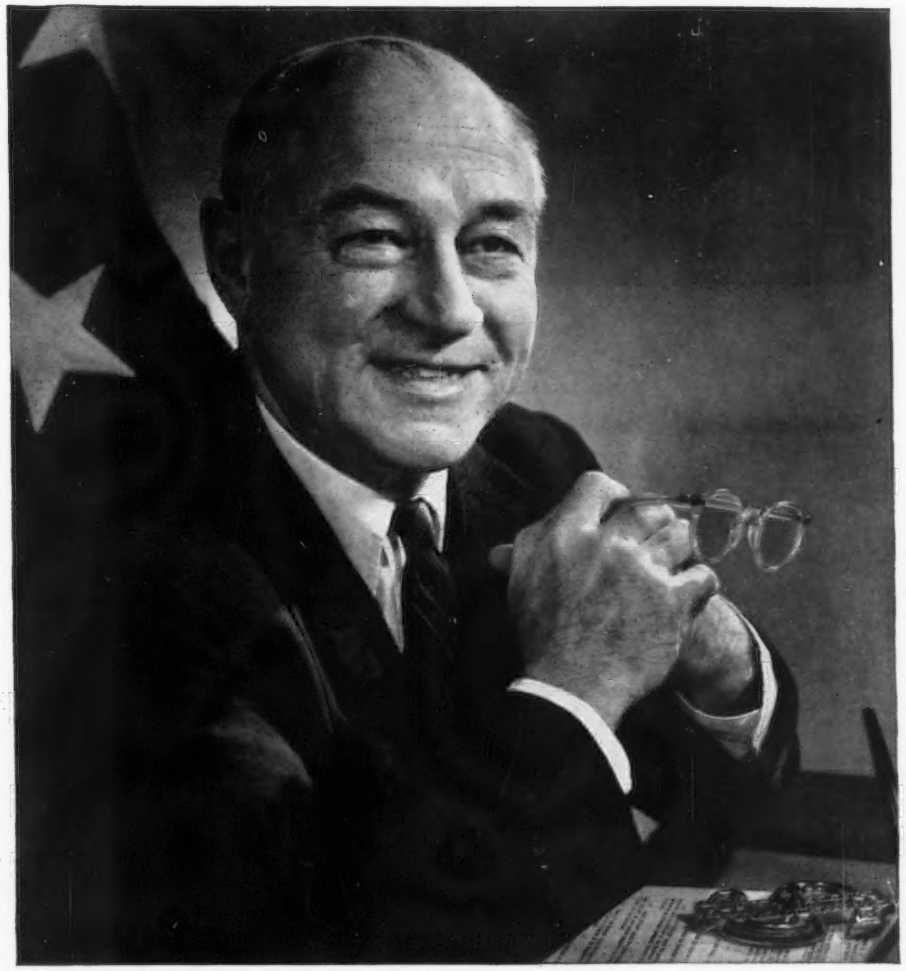

CONGRATULATIONS on Your 15th Anniversary

May 1st marked the Fifteenth Anniversary of the introduction of the Series E Savings Bonds. In a deeper sense it was *your* anniversary, because you, in 1941, helped to initiate and build a thrift movement new to America—The Payroll Savings Plan for the purchase of Series E Bonds.

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George Humphrey

Secretary of the Treasury

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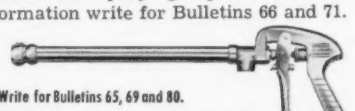

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FACTS

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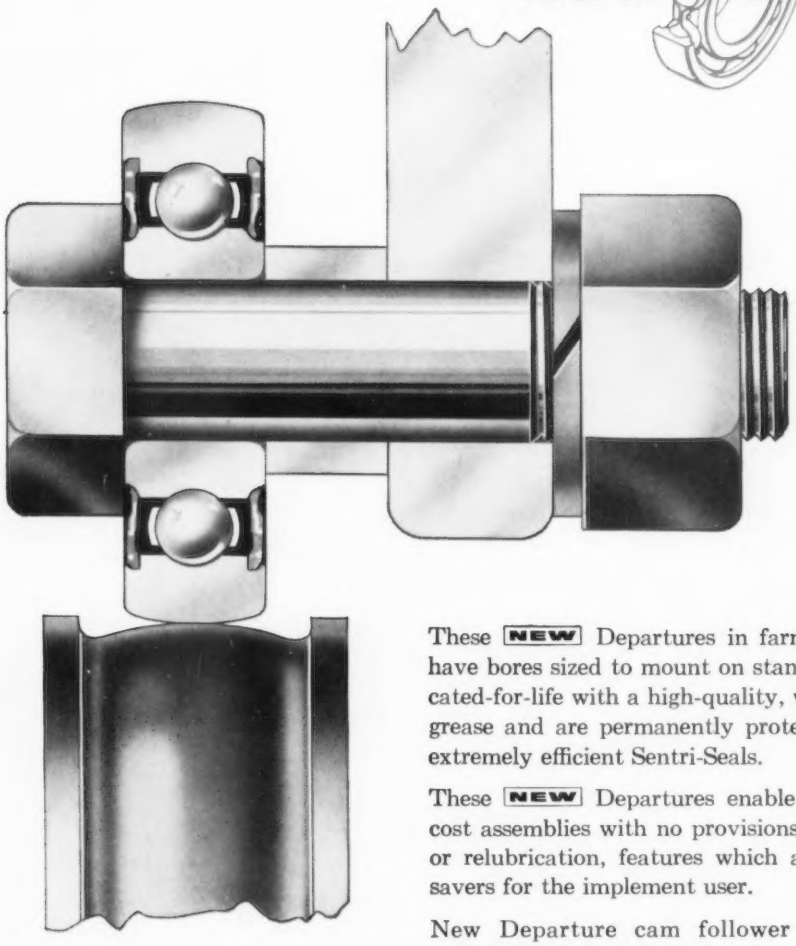

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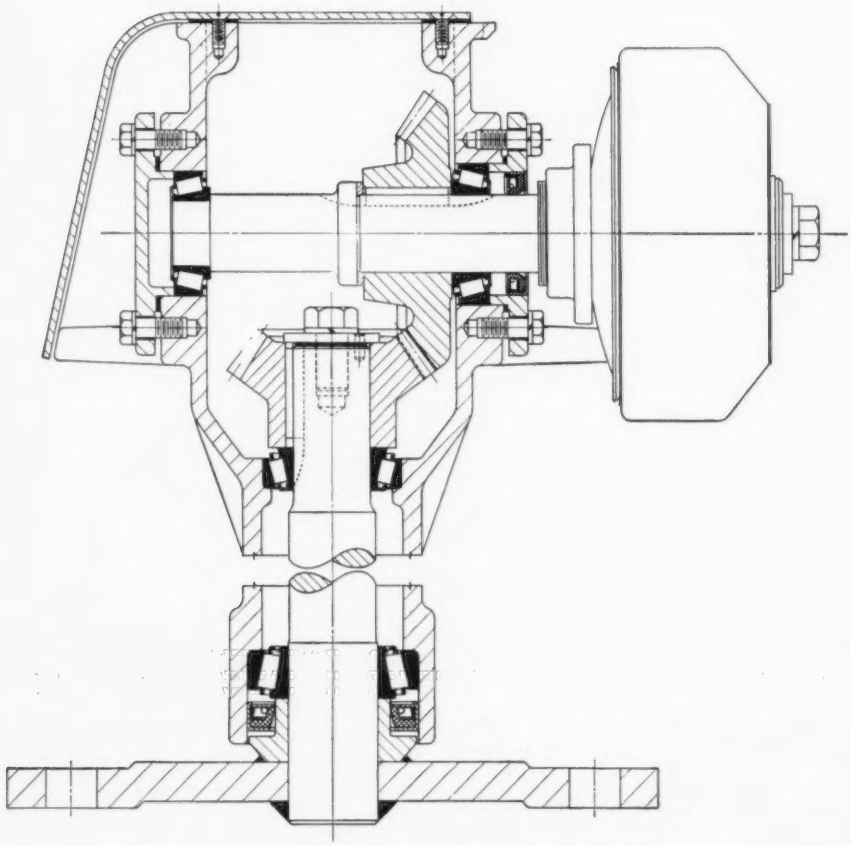

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